UNPUBLISHED
SURVEY & CONTROL
REPORTS

INTERMOUNTAIN STATION
Central Reference File
No. 3401

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

FOREST INSECT INVESTIGATIONS

Project h-1-13

BUREAU OF
ENTOMOLOGY AND PLANT QUARANTINE
RECEIVED
★ OCT 10 1942
Coeur d'Alene, Ida.
Laboratory

INSTRUCTIONS FOR MAKING BARK BEETLE SURVEYS IN THE VIRGIN PONDEROSA PINE STANDS OF OREGON AND WASHINGTON

By

W. J. Buckhorn

Senior Scientific Aide

Forest Insect Laboratory
445 U. S. Court House
Portland, Oregon
July 30, 1942

U. S. GOVERNMENT PRINTING OFFICE 60918

INSTRUCTIONS FOR MAKING
BARK BEETLE SURVEYS
IN THE VIRGIN PONDEROSA PINE STANDS
OF OREGON AND WASHINGTON

Approved by

Senior Entomologist

Submitted by

Senior Scientific Aide

Portland, Oregon
July 30, 1942

CONTENTS

	Page
I. INTRODUCTION	1
Purpose of insect surveys	1
Types of surveys	2
Data obtained	3
Survey personnel	4
II. INTENSIVE SURVEY METHODS	5
New plots	5
Old plots	6
Survey procedure	6
New plots	6
Duties of crew members	8
Old plots	10
III. SPOTTING METHODS	11
Spotters' duties	11
Agencies responsible for death of trees	14
Seasonal identification of loss	16
Marking of bug trees	20
Increment cores	22
Recording of spotting data	23
Summary of spotting data	25
IV. MAPPING METHODS	27
Compassman's duties	27
Pacing	29
Mapping	31
Map symbols	33
V. TIMBER INVENTORY CRUISES	34
Duties of crew members	36
Measuring tree heights	38
Recording and summarizing tree height measurements	40
Height curve construction	41
Volume tables	42
Recording of cruising data	44
Summary of cruising data	45

		Page
VI.	SURVEY EQUIPMENT AND ITS USE	47
	Biltmore or forest cruiser stick	47
	Measurements for construction of Biltmore rule	50
	Diameter tape	51
	Increment borer	51
	Compass and correction factors	52
	Tally register	54
	Abney level and topographic tape	55
	Spotting equipment list	57
	Cruising equipment list	58
	Working equipment list	59
	Camping equipment list	60
	Office equipment list	61
VII.	FORMS USED ON SURVEY	62
	Plot description	63
	Summary of sample plot data	64
	Section plat	65
	Spotting record	66
	Plot and physical descriptions	67
	Tree class tally	68
	Summary of tree class data	69
	Tree heights	70
	Height curve	71
	Standard height curves	72
VIII.	APPENDIX	73
	Keen tree classification	
	Tree class calculator	
	Correction factor for time of survey	
	Volume tables	

I. INTRODUCTION

Annual bark beetle surveys in the ponderosa pine stands of Oregon and Washington were first started on a continuing basis in southern Oregon in 1921, and later in Washington during 1930. These annual detection surveys have been carried on ever since and form the basis for control action and forest management plans.

The purpose of these pine beetle surveys has been fourfold; (1) To determine the yearly trend, intensity, and distribution of the western pine beetle (Dendroctonus brevicomis Lec.) and other insects associated with it in the killing of ponderosa pine; (2) to ascertain the need for artificial control work; (3) to determine the types of tree and the areas which are most susceptible to beetle ravages and which warrant first consideration in timber management plans; (4) to obtain pertinent data to be used in research phases of forest insect investigations.

Due to the seasonal character of the survey there has been a frequent turnover in field personnel. In order to facilitate training of the men and improve the quality of work it has been necessary to standardize the methods used. The methods herein described have been compiled from the standardized field methods of the Bureau of Entomology and Plant Quarantine and U. S. Forest Service.

Types of Surveys

The annual bark beetle surveys have been both extensive and intensive in character.

The extensive phase of the survey consists more or less of general observations, topographic reconnaissance, or strip counts. The information obtained is more or less general and not sufficiently accurate to permit its use for comparative purposes.

The intensive phase of the survey consists of a 100 percent cruise of all losses occurring on permanent 320- or 640-acre sample plots scattered throughout representative portions of the ponderosa pine forests of both eastern Oregon and eastern Washington.

The 320-acre plot is now standard size; while sufficiently large to give good representation, work on it can easily be completed in one day.

The high degree of accuracy obtained by this method enables the use of data obtained for comparative purposes. The data also form the basis for estimating the amount of infestation on surrounding areas when carrying out the extensive phase of the survey.

The intensive phase of the survey is carried out in both cutover and virgin stands. However, only the methods used in the virgin stands will be considered at this time.

Data Obtained

The data obtained from insect surveys ordinarily comprise information on:

(1) The number, size, and class of trees killed on a given area or plot and the insect or other agency responsible for this mortality.

(2) The distribution of loss by insect responsible, generation involved, or other agency, such as windfall, lightning, or fire.

(3) A map of the area or plot showing distribution of killed trees, grouping, and intensity of loss.

(4) Growth rate of insect-killed and green trees.

(5) An inventory cruise of the green stand is frequently made so as to relate losses to percent of stand killed and to proportion of various tree classes involved.

Survey Personnel

Crew organization. The three-man crew consisting of a crew leader and two assistants has been found to be most efficient on these surveys. This provides a compassman,[1] a cruiser,[2] and an estimator[2] for making a ten percent inventory cruise, and for spotting it provides a compassman[1] and two spotters.[3] The spotters must possess keen eyesight, good color perception, and a certain knowledge of forest insects, especially those of the bark beetle group, including their habits, life history, and character of work. To maintain the speed and accuracy of the work there must be perfect cooperation among the crew members at all times.

The crew operates under the supervision of a representative of the Bureau of Entomology and Plant Quarantine or Forest Service. The crew supervisor also carries on the extensive phase of the survey.

1/ Compassman's duties, p. 8
2/ Timber inventory cruises, p. 34
3/ Spotting methods, spotters' duties, p. 11

II. INTENSIVE SURVEY METHODS

The locations of the check plots to be established are tentatively selected in the Portland office by using available type maps, cruise figures, site data, etc. These selections are then checked in the field by the crew supervisor. If found unsatisfactory, the location is changed to some nearby section.

The survey methods on the plots involve the following field work:

New Plots

(1) Establish control lines[1] across each end of the plot to facilitate spotting[2] and cruising[3] during the initial survey and in the future.
(2) Locate, mark,[4] record,[5] and map[6] all trees killed during the past year and thus far during the current year.[7]
(3) Make a ten percent inventory cruise[3] of the green ponderosa pine stand.
(4) Take sufficient measurements of tree heights[8] to determine site[9] on plot.
(5) Secure designated number of increment cores[10] to determine rate of tree growth on plot.
(6) Complete a physical and cultural description[11] of plot.

1/ Survey procedure, new plots, p. 6
2/ Spotting methods, spotters' duties, p. 11
3/ Timber inventory cruises, p. 34
4/ Marking of bug trees, p. 20
5/ Recording of spotting data, p. 23
6/ Mapping, p. 31
7/ Seasonal identification of loss, p. 16
8/ Measuring tree heights, p. 38
9/ Height curve construction, p. 41
10/ Increment cores, p. 22
11/ Spotting methods, spotters' duties, p. 11

Old Plots

After establishment the plots are surveyed annually. All losses developing since the previous survey are spotted and mapped. A recruise of the green ponderosa pine stand is carried out at 5-year intervals. At this time increment cores are also taken--oftener if necessary.

Survey Procedure

New Plots

Establishing control line. Locate section corner of that portion of the section designated to be the plot. Starting at this corner follow original G.L.O. survey line to quarter corner. Brush out well and blaze. Measure with a 2 1/2 chain topographic tape[1] and abney level[1] and erect tally markers every 5 chains along line. Starting at first marker five chains from section corner number consecutively from 1 to 7. Place symbol "T" for tally directly above marker number.

Tally markers are to be constructed in the following manner. Build rock monument at least 16 inches in height. Make 4x6 inch blazes facing monument on two trees standing one on each side of monument and not over 16 feet distant. With keel write number of tally marker on blazes. If trees are not present use a three or four inch stake about 4 1/2 feet long. Drive into ground and build monument around it. Smooth up two opposite sides and place numbers on stake. If rocks are not available use stake and trees to mark location.

---

[1] Abney level and topographic tape, p. 55

After establishing control line No. 1 the crew returns to tally marker No. 1. Starting from this point a regular strip is spotted[1] through the plot. Upon arriving at the opposite end of plot locate section corner and establish control line No. 2, in the same manner as No. 1.

Starting through the plot from tally marker No. 1 enables the compassman to check both pacing[2] and compass declination[3] at the section corner, which reduces the possibility of a large error. Also section corners are usually much easier to locate than the quarter corners.

Upon completion of control line No. 2 the spotting may be completed in the usual manner.

A self-explanatory form, "Plot and Physical Description," is completed for each plot. See sample on page 67.

1/ Survey methods, p. 5
2/ Pacing, p. 29
3/ Compass and correction factors, p. 52

Duties of Crew Members

New Plots

Compassman:

Runs compass[1] using extreme care not to deviate from original survey line. Drags chain[2] and acts as head chain man. Assists in building of monument.

Spotter No. 1:

Acts as rear chain man,[2] carries abney level, and makes slope corrections.[2] Assists in brushing out and blazing line and building of monument.

Spotter No. 2:

Brushes out and blazes line. Secures and prepares stake. Assists in building monument. Places number of tally marker on stake or trees.

Duties of crew members in spotting new plot

Compassman:

In addition to the usual procedure, corrects compass declination[1] and completes form, "Plot and Physical Description". Extreme care must be used in writing up instructions for reaching plot, as future crews will rely on this information.

1/ Mapping methods, compassman's duties, p. 27
2/ Abney level and topographic tape, p. 55

Spotters:

As no previous spotting[1] has been done on the plot, all the past season's[2] loss is to be marked as well as that killed thus far during the current season. Secure at least 15 increment cores[3] from class 3-A trees.

Duties of crew in cruising

After the plots are spotted[4] a ten percent inventory cruise[5] is carried out in the usual manner.

1/ Spotting methods, spotters' duties, p. 11
2/ Seasonal identification of loss, p. 16
3/ Increment borer, p. 51
4/ Spotting methods, p. 11
5/ Inventory cruise, p. 34

Survey Procedure

Old Plots

Use forest map and "Instructions for Reaching Plot" to locate plot, then locate starting point, usually Tally marker No. 1. From this point the spotting crew moves through the plot, each spotter covering a 5-chain strip, marking and recording all losses developing since the last survey. The compassman maintains a true line and correct measure of distance, and maps location of all trees marked by spotters. Upon arrival at the opposite control line the crew offset to tally marker No. 3 and return to like marker on starting line. The next runs are made in a similar manner starting at tally marker 5 and returning on tally marker 7, thereby completing the plot.

Corrections must be made in the "Instructions for Reaching Plot", whenever encountering any change in the roads.

Tally markers should be replaced when found missing, and renumbered when they become illegible. Also keep control lines brushed out.

III. SPOTTING METHODS

Spotters' Duties

The spotters are responsible for the detection ("spotting") of all trees killed since the previous survey. The spotter detects the trees by noting certain external indications; namely, sickly, fading, or faded foliage; fresh or recent pitch tubes; sawdust in bark crevices; insect emergence holes; woodpecker work; and either scaling or individual holes in the bark on the bole. When one or any combination of the above indications are present, chopping through the bark usually reveals the insect broods or indications of their having been present. On green trees where external and internal indications of the presence of insects or attack are vague, care should be exercised not to injure the tree unduly in making examinations.

Having determined that a tree should be marked the spotter calls, "Bugs!" to the compassman, who then halts his line. Spotter then blazes tree.[1/] When approaching tree and while blazing tree spotter determines the year and season of death,[2/] and the agency responsible for its death.[3/] With keel he places serial number[1/] of

---

1/ Marking of bug trees, p. 20
2/ Seasonal identification of loss, p. 16
3/ Agencies responsible for death of trees, p. 14

tree on blaze. Measures diameter of tree using Biltmore stick[1] or diameter tape.[2] Determines Keen tree classification[3] of tree. Records data on spotting record.[4] Calls in serial number to compassman, who repeats number to verify it. On groups only the first and last serial numbers are called in. The serial number indicates the year of loss. All numbers under 499 indicate current loss, all above 501, past season's loss.

All marking and recording operations on both single trees and groups must be completed before calling in serial numbers. Upon receiving the number the compassman knows the spotter has completed the operation and proceeds with the line.

Spotters should cooperate in marking large groups of trees. On certain plots spotter secures increment cores,[5] usually fifteen, from designated types of trees.

Each spotter covers a five-chain, "330-foot" strip. One spotter ranges to the right, the other to the left of the compassman. The spotter should pace[6] out the width of strip until he can estimate it. Covering too wide or too narrow a strip results in either holding up the crew or missing trees. Spotters must respond to compassman's tally[7] calls to enable the crew to move in unison.

1/ Biltmore or forest cruiser stick, p. 47
2/ Diameter tape, p. 51
3/ Keen tree classification, p. 73
4/ Recording of spotting data, p. 23
5/ Increment borer, p. 51
6/ Pacing, p. 29
7/ Spotting methods, compassman's duties, p. 8

The spotter should use care when approaching control line[1] not to mark trees outside of plot.

After the field work is completed the volumes[2] are to be entered on spotting records, the plot data summarized[3] and filed properly. The increment cores must be taken care of promptly in the proper manner.[4] Spotters should cooperate in summarizing spotting data.[3] Axes must be kept sharp to insure smooth blaze on which to write.

Equipment used by each spotter in field is listed on page No. 57.

1/ Survey procedure new plots, p. 6

2/ Volume tables, p. 42

3/ Summary of spotting data, p. 25

4/ Increment cores, p. 22

Agencies Responsible for Death of Trees

While there are a great number of agencies which may cause the death of a tree, of necessity eight of the most important ones have been selected for recording. These eight agencies are listed below in the order of their importance, together with the abbreviations used in recording.1/

Dendroctonus brevicomis Lec. D.B.

The most important and common bark beetle which attacks trees above six inches in diameter.

Melanophila californica Van Dyke. F.H.

Prefers trees on hot, dry sites, frequently causing top killing.

Dendroctonus monticolae Hopk. D.M.

Generally found on north side of tree or in cool, moist sites.

Ips oregoni Eigh. I.O.

Attacks reproduction and smaller trees or tops of larger trees.

Ips emarginatus Lec. I.E.

Attacks all sizes of trees, generally found in conjunction with D.M.

Dendroctonus valens Lec. D.V.

Attacks the bases of trees. Its attacks frequently precede those of other insects.

1/ Recording of spotting data, p. 23

Fire. F.

Trees must have all needles scorched.

Lightning. L.

Tree must be shattered. One stroke down a side is insufficient to cause death.

Wind Throw. W.T.

All wind thrown trees are recorded on a separate spotting record labeled "Wind Throw" in upper right hand corner.

Unknown. U.

To be used when cause of death of tree cannot be ascertained.

Other important agencies contributing to the death of a tree to be entered under "Remarks".

For further reference on the insects each crew will be provided with one copy of USDA Miscellaneous Publication #273, "Insect Enemies of Western Forests".

Seasonal Identification of Loss

The identification of beetle-killed trees by year and by season is undoubtedly the most difficult phase of the spotter's work. As the surveys are usually conducted during the season of beetle activity, attacks continue after the plots have been spotted, resulting in a portion of each year's loss remaining unmarked until the survey of the following year. This necessitates marking portions of two years' losses on each annual survey, and requires two annual surveys to complete the loss data for one year.

For comparative purposes these losses are recorded by year of death and season of attack. The seasons are referred to as summer or winter and abbreviated to S. and W.; S. trees are those which were attacked and in which the brood developed and emerged during the summer; W. trees are attacked late in the summer and in the fall, the broods overwintering in or under the bark and emerging the following spring.

While attacks occur with greater intensity at certain periods, some occur throughout the season, resulting in considerable variation in brood stages and tree condition at all times. Further variations are caused by species of insect attacking, exposure, elevation, latitude, type of soil, and weather conditions. As a result of these variations none of the characters used in seasonal identification have proven infallible once the brood emerges.

Following are characters that may prove helpful in identification of D.b. trees during the months of August and September.

(1) Loss of Previous Year

(a) Summer brood, attacks occur early in spring to late in summer.

Foliage. Dark red. Many of long needles fallen. Short needles still on ends of twigs.

Bark. Usually dry and loose, with loose boring dust under bark. Pitch tubes hard and yellow. Many D.b. emergence holes. A number of large oval holes. No fresh woodpecker work. Old work, may consist of light to moderate scaling considerably weathered. Also many small round woodpecker holes through bark. Frequently many hard, dry fungus fruiting bodies, considerable portion of which have broken open or fallen.

Wood. Usually dry and checked. Much stain. Occasionally punky. Frequently many worm holes in sapwood.

Insects. Only a few secondary insects.

(b) Winter brood. Attacks occur late in summer until cold weather.

Foliage. Sorrel to red. Needles normal length. Some fallen.

Bark. Usually loose. Boring dust generally loose. White dust common in crevices. Pitch tubes becoming hard and yellow. Many D.b. emergence holes in bark. Some large, oval holes. Heavy woodpecker work frequent. None recent. Fungus fruiting bodies dry and hard, few in number.

Wood. Mostly dry, occasionally moist. Bluestained. A few small worm holes.

Insects. No D.b. Many secondaries. An occasional roundheaded borer larva.

(2) Loss of Current Year

(a) Summer brood. Attacks occur from early spring to late summer.

Foliage. Green fading to sorrel. No loss of needles. New growth short on ends of twigs.

Bark. Fairly loose and moist. Red and occasionally white boring dust in crevices. Pitch tubes red and becoming hard. May or may not be numbers of D.b. emergence holes. No large oval holes. Woodpecker work light to moderate. Frequently only small round holes through bark. Fungus fruiting bodies may be infrequent.

Wood. Moist with considerable blue stain. May be a few small worm holes.

Insects. On trees attacked early in season emergence of D.b. brood complete, later trees may have larvae, pupae, and new adults. Many secondary insects both in adult and larval forms. Round-head borers may range from small to full-grown larvae.

(b) Winter brood. Attacks occur in late summer and until cold weather.

Foliage. Fresh green to straw yellow. Fully developed needles.

Bark. Moist and generally tight. Red dust in crevices. Pitch tubes soft and red. Insect holes few. No large oval holes. Woodpecker work becoming prevalent. No fungus fruiting bodies.

Wood. Moist, clear or slightly blue stained. No worm holes.

Insects. D.b. new attacks, parent adults, eggs or larvae. On advanced trees may be a few small to half grown roundheaded borer larvae. May be clerid adults on bark. Few secondary insects under bark.

Marking of Bug Trees

After having determined that a tree requires marking, at eye level on north side make a smooth blaze at least 4 inches wide and 8 inches in length. With blue or black keel, using considerable pressure, print in horizontal position at top of blaze last two digits of year in which tree was killed.1/ Directly under year of death place season of brood, using S. or W.1/ Under Season place serial number of tree. On each plot serial numbers for the past year's loss start at 501 and for the current year's loss at 1. Following is an example of marking on the 1941 survey.

Past year's Loss		Current year's Loss	
40 S	40 W	41 S	41 W
511	516	25	32

1/Seasonal identification of loss, p. 16

The spotters use the serial numbers in blocks of one hundred each. One spotter uses the blocks starting at 1 and 501, and the other uses the next block starting at 101 and 601. Upon completion of one block of numbers the spotter skips the next block using the one following. For example, the spotter using numbers 1 and 501 next uses 201 and 701.

Axes must be kept sharp to insure a smooth blaze on which to write.1/

The current year's wind throw are blazed on top side 4 1/2 feet from stump, and are marked with year and serial number, using the same serial numbers as for standing trees.

1/ Seasonal Identification of Loss, p. 16

Increment Cores

Select trees on well-drained sites from which to take cores. The wood of the increment core is to be four inches long. Cambium is to be left on core. The four-inch length will fit into a P.A. tobacco can, which makes an excellent container in which to collect in the field.

While holding core on the extractor, with indelible pencil clearly mark on each core: (a) D.B.H.; (b) tree class; (c) if bug tree, serial number; (d) T. R. sec.; (e) date taken.

Upon completion of the plot secure all cores for plot with rubber band, then lightly roll in 5 x 8 sheet of paper. Leave ends of roll open for ventilation to prevent moulding. On outside of paper write name of forest, plot, T. R. sec., and date taken. Keep bundles of cores in well-ventilated container.

Recording of Spotting Data

The method of recording spotting data is shown on sample spotting records on page No. 66. Each spotter uses three sets of these records: One for past year's loss,[1] one for current year's loss,[1] and one for current year's wind-thrown trees.

Fill out headings on each record. Place name of forest above Project Area. Behind Project Area place area name and unit name behind Unit. Cross out "Camp No." and substitute "Plot". In first column above "Tree No." write in year of loss.[1] Under "Tree No." enter serial numbers[2] of trees marked. Serial numbers of groups to be enclosed with a bracket placed in front of numbers. To be considered a group on Spotting Record all trees must be of like season, either all S. or all W.[1] However, in mapping[3] both summer and winter trees standing together will be considered a group.

Under "Killed By" enter symbol of agency responsible for death of tree.[4] Under D.B.H. enter diameter of tree at breast height. Column under "Logs" remains blank as no log lengths are taken. Upon completion of field work on plot, from proper volume table for plot[5] select volume for each tree and enter in "Volume" column.

1/ Seasonal Identification of Loss, p. 16
2/ Marking of Bug Trees, p. 20
3/ Mapping, p. 31
4/ Agency Responsible for Death of Tree, p. 14
5/ Height Curve Construction, p. 41

At the top of next column write in heading, "Season". In this column enter season of brood, using S. or W.[1] At the top of the next or seventh column write in "Tree Class". In this column enter the age and vigor classification[2] of each tree. Under "Remarks" enter any pertinent remarks as to condition of brood or tree.

Windthrow

Windthrown trees of the current season are to be entered on a separate spotting record. This record is to be labeled "Windthrow" in upper right hand corner of record. Serial numbers[3] to run consecutively for both windthrown and beetle killed trees. Record same data as for bug trees.

1/ Seasonal Identification of Loss, p. 16

2/ Keen Tree Classification, p. 73

3/ Marking of Bug Trees, p. 20

Summary of Spotting Data

All spotting data is summarized separately by year of loss, either past or current, and by season of loss, summer or winter (S. or W.). Total the trees and volumes on each record and place at bottom of sheet. See sample record on page 66. Next sum up loss totals for year and enter data under "Remarks" on map of that year, as shown on sample map on page 65. Place season first, S. above and W. below, then number of trees for each season followed by volumes, with totals under each.

In addition to summarizing the loss by trees and volume a summary is also made of the number and size of the current loss groups and the total trees of the past season's loss. This summary is to be completed on the form, "Summary of Sample Plot Data". A completed sample is shown on page 64. This form is divided into two sections, "New Loss" in the upper portion and "Old Loss" in the lower portion. Under the "New Loss" enter by seasons the number of group, average size of group, number of trees in the group, and the number of single trees. Total both ways. The total is to be the same as on current loss map. Leave blank all of the next items except "Total Trees per Section" which is to be completed.

In the "Old Loss" division enter under "Newly Marked" total number of last season's loss marked. The amount of last season's loss marked during the previous survey was entered under "Previously Marked" by the Portland office. Find the sum of these losses and place total in proper column.

To lessen the danger of lost data file soon as summarized. Place each year's records together with map on top and fasten with "Gem" clip, then place all records in following order: On top, "Summary of Sample Plot Data," next "Current Season's Loss," and last "Past Season's Loss." Fasten with clips. Place in plot envelope and file in office box.

Uncompleted data must not be allowed to accumulate.

IV. MAPPING METHODS

Compassman's Duties

(1) The compassman is responsible for directional and distance guidance of the crew. He locates section corner of plot and starting point on control line,[1] which usually is tally marker No. 1. Using a staff compass[2] which has been corrected for magnetic declination[2] to that given in Plot Description,[3] and by pacing[4] to measure distance, he runs four lines, each 80 chains in length, at 10-chain intervals parallel to the longitudinal axis of each 320-acre plot. The first line starts at tally marker[1] No. 1 and proceeds to like marker on opposite control line,[1] then offsets to tally marker No. 3 and returns to tally marker No. 3 on starting line. The third line starts from tally marker No. 5, the fourth line returning on marker No. 7. He must inform the spotters when starting through and completing the strip. He calls out every tally on the strip[4] as this is the only means the crew has of keeping together in rough or bushy country. He should never be more than a tally ahead or behind the spotters.

1/ Survey Procedure New Plots, p. 6
2/ Staff Compass and Correction Factors, p. 52
3/ Plot Description, p. 63
4/ Pacing, p. 29

(2) When a spotter calls, "Bugs!" indicating having found a tree requiring marking, the compassman responds to the call and halts his line until receiving the serial number[1] of the tree, which spotter does not call until marking is completed. Compassman repeats number to spotter for verification, plots[2] the number on the proper map[2] for the year of loss[2] and proceeds with the line.

The tree number indicates the year of loss.[1] All serial numbers above 500 are the past season's loss; all serial numbers under 500 are the current season's loss.

On the current season's loss map[2] the compassman also maps all physical and cultural features using standard map symbols.[3]

(3) On designated plots he secures sufficient tree height measurements[4] to establish height curve for plot.[5] The measurements are to be recorded on form "Tree Heights on Permanent Sample Plots."[6] See sample form on page 70.

(4) Upon completion of field work on plot, in cooperation with spotters, he places summary of each year's loss on proper maps.[7] On plots where tree heights were taken he summarizes data and plots height curve.[5]

Equipment used by compassman in field is listed on page 57.

1/ Marking of Bug Trees, p. 20
2/ Mapping, p. 31
3/ Map Symbols for Use on Survey, p. 33
4/ Measuring Tree Heights, p. 38
5/ Height Curve Construction, p. 41
6/ Recording & Summarizing Tree Height Measurements, p. 40
7/ Summary of Spotting Data, p. 25

Pacing

Pacing is to walk with regular steps; to measure by strides. The military pace is the length of step in walking measured usually from the heel of one foot to the heel of the other foot; ordinarily 2.5 feet.

The pace referred to and used by woodsmen is a stride or Roman pace; the distance covered in walking from the heel of one foot to the heel of the same foot, a distance of approximately 5 feet. The present measurement of a mile originated from the 1,000 paces used as a measurement of distance covered by the marching Roman legions.

In pacing take a natural gait. Do not try to fit your pace to a specified distance, rather find out the distance your natural pace will cover. Among individuals, paces per mile will vary from 880 to 1060 or more.

The General Land Office surveys established horizontal measurements. Therefore when hills are encountered the distance travelled is actually greater than the surveyed distance. This increase of distance must be compensated for. Compensation must also be made for the shorter pace taken when ascending or descending hills, brush and other obstructions. This is done by skipping a count every few paces or often as necessary. Considerable practice is required before a satisfactory ratio can be established for various grades.

The following table may be useful as a guide.

Percent of Slope	Ascending		Descending	
	Step	Skip	Step	Skip
60	1	1	3	2
30	3	1	7	2
20	5	1	10	1
10	7	1		

Care must also be exercised to prevent overpacing when going down a gradual slope.

In pacing, the distance of 5 chains is commonly referred to as one tally. There are 16 tallies per mile. A pacing table should be built up to show the number of paces required for each consecutive tally from 1 to 16. With the aid of this table the pacer's position in the mile can quickly be determined on a map.

Following is a pacing table for 60 paces per tally.

Tally No.	No. of Paces
1	60
2	120
3	180
4	240
5	300
6	360
7	420
8	480
9	540
10	600
11	660
12	720
13	780
14	840
15	900
16	960

Many methods may be employed to keep track of the number of paces taken per mile. The simplest and by far the most accurate is to record each pace on a tally register.[1] This operation soon becomes almost automatic, leaving the mind free for other things.

Mapping

The type of map used on check plots, the methods of plotting insect-killed trees marked by spotters, and mapping of topographic and cultural features are shown on the sample "Section Plat" on page 65. Two section plats are required per plot, one for past season's loss and the other for current season's loss. Mapping of physical features is confined to current loss plat.

(1) Plotting of trees

The number within the circle, as shown on the sample Section Plat, represents the quantity of trees within a group. Numbers immediately above or below the circle represent the first and last serial numbers[2] of the trees within the group. All numbers used in plotting must have tops toward north.

(2) Map legend

Forest Service map symbols with a few additions are used to show physical and cultural features. See Map Symbols for use on Forest Insect Surveys on page 33. Openings or changes in timber type of 5 chains or more in width are to be mapped.

---

[1] Tally register, p. 54
[2] Marking of bug trees, p. 20

(3) Year of loss

The year of loss each map represents must be clearly shown under "Remarks" on the Section Plat. Serial numbers[1] 1 to 500 represent current season's loss. Those over 500 represent past season's loss.

(4) Plot loss summary

A summary of each year's loss by season, trees, and volume is to be shown under "Remarks." See sample Section Plat.

---

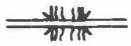
[1] Marking of Bug Trees, p. 20

MAP SYMBOLS FOR USE ON FOREST INSECT SURVEY

PRIMARY ROADS

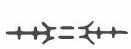
SECONDARY ROADS

TRAILS


BRIDGES

FORDS

RAILROAD

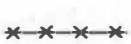

RAILROAD TUNNEL

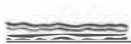
TELEPHONE LINE ALONG ROAD

TELEPHONE LINE ALONG TRAIL

TELEPHONE LINE

FENCE


FENCE ALONG LAND LINES


RIVER

SMALL STREAM

INTERMITTENT STREAM

FLUME

CANAL OR DITCH

POND OR LAKE

RESERVOIR AND DAM

SPRING

SPRING WITH TROUGH

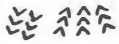
WELL

PEAK

RIDGE

CLIFFS

RIMROCK


ROCK OUTCROPPINGS

MARSH OR GRASSLAND

TIMBER TYPE BOUNDARIES

CORNER POSITIVELY IDENTIFIED

CORNER FOUND, NOT POSITIVELY IDENTIFIED

CORNER SEARCHED FOR BUT NOT FOUND

MINE OR QUARRY

CORRAL

SALT TROUGH

SAWMILL

FOREST CAMP

LEANTO

RANGER STATION

SCHOOLHOUSE

HOUSE

SMALL TOWN

BENCH MARK WITH ELEVATION

TRIANGULATION STATION

V. TIMBER INVENTORY CRUISES

A ten percent inventory cruise of the ponderosa pine stand is made on all new plots when established[1] and on the old plots at certain intervals.

The cruise consists of running four strips each 80 chains in length and one chain "66 feet" in width on each 320 acre plot. The strips run from tally markers 1, 3, 5, and 7 to like markers on opposite control line.[1] Diameter measurements[2] [3] are taken, by two inch classes, of all green ponderosa pine and free standing ponderosa pine snags having diameters 9.6' D.B.H. and over. Trees having centers exactly 33 feet from compass line to be omitted. Use Biltmore stick or diameter tape to secure measurements. Classify all green ponderosa pine according to the Keen tree classification.[4]

Current year's beetle losses[5] on the strip are to be classed as green trees. Last year's losses[5] will be classed as snags. For this purpose the plots should be spotted before cruising. Trees forking above breast height, 4 1/2 feet above ground, are to be considered as one tree. Trees forking below breast height are to be measured as two trees.

1/ Survey Procedure New Plots, p. 6
2/ Biltmore or Forest Cruiser Stick, p. 47
3/ Diameter Tape, p. 51
4/ Keen Tree Classification, p. 73
5/ Seasonal Identification of Losses, p. 16

Take tree height measurements[1] with abney level to determine site[2] of plot.

Secure at least fifteen cores[3] from green class 3-A trees. Trees should be well distributed over the plot. It is usually more convenient for both spotters to take the cores while spotting the plot.

1/ Measuring Tree Heights, p. 38

2/ Height Curve Construction, p. 41

3/ Increment Cores, p. 22

Duties of Crew Members

Compassman

Runs compass line[1] and measures the distance by pacing.[2] Informs estimator when reaching end of each quarter section. Drags 2 1/2 chain steel tape. The tape is used to measure distance[3] in taking tree heights.[4] It also serves as a base from which the cruiser can gauge his distance. Takes height measurements[4] of trees of all degrees of age, vigor, and dominance[5] along compass[1] line from which to determine site[6] of plot. Secures diameter measurements of these trees with diameter tape[7] or from cruiser. Summarizes tree heights[8] and determines site[6] of plot.

Cruiser

With Biltmore stick[9] or diameter tape[7] secures diameter measurements of all ponderosa pine live and free standing snags 33 feet on each side of compass line. Calls diameters to estimator. After calling out diameter remains at tree until answered by estimator. Holds rear end of chain to enable compassman to obtain correct distance for measuring tree heights.

Assists estimator to summarize "Tree Class Tally"[10] and "Summary of Tree Class Tally".[10]

1/ Spotting Practice, Compassman's Duties, p. 27
2/ Pacing, p. 29
3/ Topographic Abney Level and Topographic Tape, p. 55
4/ Measuring Tree Heights, p. 38
5/ Keen Tree Classification, p. 73
6/ Height Curve Construction, p. 41
7/ Diameter Tape, p. 51
8/ Recording and Summary of Tree Heights, p. 40
9/ Biltmore or Forest Cruiser Stick, p. 47
10/ Summary of Cruising Data, p. 45

Estimator

Determines the Keen tree classification[1] of all green ponderosa pine measured by cruiser. Enters green tree data and snag measurements in proper space on tree class tally sheet.[2] Changes tally sheets for each quarter section. Repeats diameter measurements called by cruiser.

With the assistance of the cruiser summarizes "Tree Class Tally"[3] and "Summary of Tree Class Tally."[3]

In order to maintain the accuracy and speed with which the cruise is carried on there must be complete cooperation between crew members at all times.

Equipment used by the crew in the field is listed on page 57.

---

[1] Keen tree classification, p. 73
[2] Recording of cruising data, p. 44
[3] Summary of cruising data, p. 45

Measuring Tree Heights with Topographic Abney Level

Measure one chain (66 feet) from center of tree. The topographic tape[1] can be used to advantage on sloping ground. With topographic abney level take two readings on tree, one at ground line, the other at top of tree (to topmost branches).

Three possible situations may be encountered in taking these readings.

(1) When observer's eye is on a level with the ground line. In this case the abney reads zero on ground line and a plus reading on the top height. The tree height is the abney reading on top height.

(2) When observer's eye is above the ground line. In this case the abney reading will be minus on the ground line and plus on the top height. Tree height is then the sum of both readings.

(3) When observer's eye is below ground line. In this case plus readings will be obtained on both ground level and top height. Tree height is the difference between the greater and lesser readings.

---

[1]/Topographic Abney Level and Topographic Tape, p. 55

On the taller trees readings should be taken at two chains' distance, as a better view may be obtained of the tree. At two chains the readings must be doubled for the correct height. Select only trees in vertical position, as leaners will give incorrect measurements.

Recording and Summarizing Tree Height Measurements

Tree height measurements are to be recorded separately for each quarter section, using the form "Tree Heights on Permanent Sample Plots." See sample on page 70.

One form is required per 320-acre plot. The form has two divisions, one for each quarter section. Designate the quarter section by NW, NE, SW, or SE. Cross out class designations, as they are no longer used. Enter measurements in first column of each division. Three measurements should be taken for all diameter classes for each quarter section or 130 per plot. The larger diameter classes should be well represented.

Summary of Tree Height Measurements

Average the height for each diameter class for each division or quarter section. Place these average heights in column No. 2 of each division.

Height Curve Construction and Volume Table Determination

Plot average tree heights of both quarter sections over diameter on graph paper having 20 squares per inch both ways. (See sample on page 71.) A curve should then be carefully fitted to the points. This curve should then be compared to the standard set of curves on page 72. The number of the standard curve which most closely fits the plot curve represents the volume tables to be used on the plot.

Extreme care should be exercised in drawing the height curve and in choosing the corresponding volume table, as the table chosen will be used for all future volumes taken on the plot.

The plot curve is to be clipped to the tree height form and filed in the Plot envelope.

Volume Tables

The volume tables used on previous surveys were based on both diameter and height measurements. The estimating of tree heights proved such a prolific source of error it has been discontinued and only the diameters are now taken.

The volume tables now used represent the average volume per tree for each diameter on a given site. One set of these volume tables has been constructed for each site. The number of the set corresponds to that of the site. Thus Set No. 4 represents Site No. IV. Each set consists of five or six individual volume tables representing the volume per tree for approximately every five feet of increase in height of tree.[1] These tables were numbered consecutively from best to poorest range within each site. Table sets Nos. 4 and 5 contain six volume tables apiece. Table set No. 3 contains 5 volume tables. See Volume Tables, page No. 42.

The tables are designated first by set number and then by table number. Thus 4-4 indicates set No. 4, table No. 4. The volume table to be used on each plot is shown in the upper right hand corner of the "Plot Description." On new plots and those on

---

[1] See Standard Height Curves, p. 72

which height curves are being established during the current survey the correct table to be used will be determined by the height curve.[1]

Separate sets of tables are to be used for the live and dead trees. The set for the dead trees is labeled, "Insect Killed Trees" and for the live trees, "Green Trees." The Green Tree set is divided by "Mature" and "Immature Stand." The immature volumes are to be used for Class 1 and 2 trees, Mature for Class 3 and 4 trees.[2]

---

[1] Height curve construction and volume table determination, p. 41

[2] Keen Tree Classification, p. 73

Recording of Cruising Data

Cruising data are to be recorded on form "Tree Class Tally." (See sample on page 68.) Two of these forms, one for each quarter section, are required per 320-acre plot. Fill in all information asked for on form heading. One correction must be made in heading. Cross out "Forty" and substitute "1/4 Sec." The quarter section is to be designated by NE, SE, SW, or NW.

Snags are to be recorded by diameter classes only under "Dead Trees." Certain of these forms lack this column. On these forms record the snags in the D.B.H. column. Green trees are to be recorded by diameter and according to the Keen tree classification.[1] For diameters larger than provided for, write in diameter on blank lines at bottom of sheet.

Use the dot and bar system of recording trees. One dot equals one tree. One bar equals one tree. Place the dots for the first four trees recorded in each diameter and tree class division to form a square. Next connect the four dots with four bars, enclosing the square. Dots and bars now represent eight trees. Lastly, place two more bars diagonally across the box connecting all four corners, completing the unit. The four dots and six bars used to complete the unit represent a total of ten trees.

---

[1] Keen tree classification, p. 73

Summary of Cruising Data

(1) Summarize "Tree Heights"[1] and plot height curve[2] to determine the proper volume table[2] for plot.

(2) Total data on "Tree Class Tally" forms by diameter and vigor classes.[3] Snags are totaled separately and are not included in the green tree total.

(3) Summarize tree class tally data on form, "Summary of Tree Class Tally." (See sample on page 69.) One of these forms is used for each quarter section, two per plot. All green tree data on the "Tree Class Tally" are transferred to identical positions on the "Summary of Tree Class Tally" form. Figures are used to denote the number of trees represented by the dots and bars, using a red or blue pencil. Place figures in upper portion of each square. Enter snags by diameter class in unmarked column in front of "Total." Label this column, "Snags."

(4) Determine volumes of green trees from proper volume table for plot.[2] Care must be taken to use the mature volume table for class 3 and 4 trees and the immature table for class 1 and 2 trees.[3] Total the volumes for the trees in

---

[1] Recording and summarizing tree height measurements, p. 40
[2] Height curve construction and volume determination, p. 41
[3] Keen tree classification, p. 73

each square and enter in lower portion of square. No volumes are entered for snags. Scribner Decimal "C" method is used in recording and computing all volumes.

(5) Total the number of snags. Total both number of trees and volumes of the green stand by diameter classes and by vigor classes. The sums of the green stand totals, both trees and volume, are placed in the lower right hand corner of each sheet. Care must be exercised not to include the snags with the green stand.

Clip Tree Class Tally sheets crosswise to upper portion of "Summary of Tree Class Tally." Fold lower half over Tree Class Tally. Place in plot envelope.

Tree heights are summarized by compassman.

"Tree Class Tally" and "Summary of Tree Class Tally" forms are summarized by cruiser and estimator.

VI. SURVEY EQUIPMENT AND ITS USE

Biltmore or Forest Cruiser Stick

Use of the Biltmore stick provides a quick and sufficiently accurate method of securing diameter measurements of both insect-killed and live trees on the regular survey work.

While sticks are manufactured for different lengths of reach--that is, the distance at which the stick should be held from the eye--a 25-inch-reach stick is suitable for most men and is furnished for use on the survey.

In taking measurements grasp the stick near the middle with thumb and fingers of right hand, thumb to be above, resting on Biltmore side of stick, fingers to be underneath on the Merritt hypsometer scale. Stand erect, face tree squarely, place beveled edge of stick squarely against tree at breast height (4 1/2 feet) and 25 inches from eye. Hold stick horizontal and at right angles to line of sight. Bring left end of stick to a point where line of sight intersects left side of tree. The diameter will be found at point on stick where line of sight intersects both stick and right side of tree. Use one eye only and do not move head while measuring.

The distance between eye and stick will be a prolific source of error unless care is exercised to insure its correctness. An excellent method to establish this distance is by using a piece of string with a loop large enough to slip up and down the stick readily. Tie a knot in the string at a distance of 25 inches from top or sharp edge of stick. Place knot between teeth and slide loop to that part of stick in contact with tree; extend arm far as string will permit, which should be the correct distance of 25 inches. Use string for several days or until sure of distance. Measurements should be checked with diameter tape at frequent intervals throughout season, especially on irregular-shaped trees.

As the diameters of trees increase toward the maximum it becomes increasingly difficult to obtain accurate measurements with a Biltmore stick. Therefore a diameter tape should be used to secure measurements of all trees 40 inches D.B.H. and over.

Trees forking over 4 1/2 feet above ground are considered as one tree. Trees forking under 4 1/2 feet are considered as two separate trees and measured accordingly.

Sources of Error in Using Biltmore Stick

The most common sources of error in using a Biltmore stick are listed in order of their importance.

(1) Incorrect distance between eye and stick.

(2) Turning head to read diameter.

(3) Not holding stick horizontally.

(4) Not holding stick at right angles to line of sight, resulting in one end of stick being nearer eye than other end.

(5) Stick held too high or too low.

Measurements for Construction of Biltmore Stick

Under certain conditions it may become necessary to construct a Biltmore stick. Sets of measurements for construction of sticks for various lengths of reach are shown on the following table.

MEASUREMENTS FOR CONSTRUCTION OF BILTMORE RULE

Diameter Breast High	Distance from eye to tree in inches				
	23	24	25	26	27
	Actual distance to be marked on stick in inches				
6 in.	5.29	5.31	5.34	5.36	5.38
8	6.82	6.85	6.90	6.93	6.96
10	8.26	8.31	8.36	8.41	8.46
12	9.67	9.69	9.76	9.83	9.89
14	10.92	11.01	11.09	11.17	11.25
16	12.13	12.26	12.36	12.46	12.56
18	13.34	13.47	13.59	13.70	13.81
20	14.46	14.61	14.75	14.89	15.02
22	15.55	15.72	15.89	16.05	16.19
24	16.60	16.79	16.95	17.11	17.30
26	17.62	17.82	17.99	18.20	18.38
28	18.59	18.82	19.04	19.24	19.44
30	19.55	19.79	20.02	20.24	20.46
32	20.47	20.72	20.97	21.21	21.45
34	21.36	21.64	21.91	22.16	22.42
36	22.23	22.52	22.81	23.08	23.33
38	23.07	23.38	23.69	23.99	24.27
40	23.91	24.24	24.56	24.86	25.16
42	24.71	25.05	25.38	25.71	26.03
44	25.50	25.87	26.23	26.55	26.89
46	26.26	26.65	27.01	27.36	27.72
48	27.01	27.41	27.80	28.17	28.54
50	27.76	28.18	28.57	28.96	29.34
52	28.48	28.91	29.32	29.72	30.11
54	29.18	29.63	30.06	30.48	30.89
56	29.88	30.35	30.79	31.22	31.64
58	30.56	31.04	31.49	31.94	32.38
60	31.23	31.73	32.20	32.67	33.12

From "Notes on the Biltmore Stick" by Donald Bruce, Proceedings of the Society of American Foresters, Vol. IX, No. 1, Jan., 1914.

Diameter Tape

One side of tape is graduated in feet and tenths of feet. The other side is graduated in the diameter equivalents of circumferences in consecutive diameter inches and tenths of inches.

When the hook at end of tape is caught in bark the diameter scale on tape is out. Place tape in horizontal position around tree at breast height (4 1/2 feet). Read diameter at start of graduations (not at hook). Diameters are taken in two-inch classes on the even numbers on all trees over 9.6 inches in diameter.

Keep tape oiled and free of rust. Do not kink, as breakage is likely to occur.

Increment Borer

The 10-inch increment borer is furnished as standard equipment on the insect surveys.

At convenient height on tree start borer in thick bark with bit pointed towards center of tree. Hold handle slightly above horizontal to allow for tree taper. Avoid flutes or the flat sides on tree.

Extreme care must be used to protect cutting edge of bit, as only a slight nick will render it worthless. Use care to avoid bending extractor. Clean bore of bit with kerosene or stove oil occasionally to prevent an accumulation of pitch, which will cause cores to stick. In damp weather keep oiled to prevent rust.

Compass and Correction Factors for Compass Alignment

A staff compass, Forest Service Standard or Geologist's type, is used to obtain directional guidance on the plot work. With care, surprisingly good results may be achieved with these compasses. However, for satisfactory performance the compass must be in good condition--needle lively, sights in alignment, and hair taut. The ball and spindle joints on mounting must work smoothly.

For speed and convenience in setting up the compass mount on and securely fasten to "Jacob's staff" the spindle and ball joint portion of the mounting, screw spindle socket portion into base of compass, using sufficient force to prevent its working loose.

Set up compass immediately upon arrival at starting point. Raise sights, level compass, allow needle to settle, and bring north end of needle into perfect alignment with zero or 90 degree graduations on arc. As few compass needles are in perfect alignment, always read north end of needle. Take sight, fixing clearly in mind a very definite object, and go to it. If at any time uncertainty exists as to sight, set up immediately and sight again.

Do not attempt to sight across wide canyons, as the sight will invariably be lost while traversing the canyon. Rather take a sight to the bottom and another sight out. Before removing compass from staff always lift needle from pivot. Lower sights with hair underneath.

Declination

Declination found to be satisfactory on old plots is given in "Plot Description." However, correction may be necessary, as individual compasses vary.

On new plots start with general declination for area and make necessary corrections as work progresses.

Correction Factors for Compass Alignment

Error in Chains	Corrections in Minutes and Degrees
0.50	0° 21'
1.00	0° 43'
1.50	1° 05'
2.00	1° 26'
2.50	1° 47'
3.00	2° 09'

Corrections apply to lines one mile in length, double corrections for lines one half mile in length.

If compass line falls to right of true line, the correction is to be added to declination setting, if to left subtract the correction.

Tally Register

The tally register or counter records from 1 to 999. It operates by depressing a plunger, recording one digit each time depressed. Most models are provided with two buttons on the back for resetting.

The tally register is so constructed that it is most conveniently held in left hand, and provided with a ring to slip over the middle finger.

In counting paces the plunger is depressed each time the left foot hits the ground. In a short time this operation becomes almost automatic.

An extra spring to operate the plunger should be carried at all times as they occasionally break without warning. A pocket knife may be used to remove the screws to insert the new spring.

Topographic Abney Level and Topographic Tape

Topographic Abney Level

The topographic abney level used on forest insect surveys is similar in construction to the percent and degree abneys, the basic difference being in the design of graduations on the arc. It is recognizable by the word "Topographic" at one end of the arc and "Rise in feet per chain" at the other end. This arc is so divided that the graduations represent one foot of difference in elevation for every chain (66 feet) horizontal distance. The use of the abney on the forest insect surveys is (1) to obtain chainage corrections on slopes and (2) to measure the height of trees to obtain site quality.

Topographic Trailer Tape

The 2 1/2 chain length topographic tape is used on forest insect surveys. The tape is graduated for 2 chains of its length into links (100 links equal one chain) and the additional 1/2 chain length is graduated to correspond to slope readings with topographic abney so that for any abney reading on slopes up to 50, the horizontal distance of two chains may be obtained by holding the rear of the tape at the corresponding reading.

For example, if the abney reading is 40, the rear chain man will permit the tape to be drawn out past the two chain markers until the graduation 40 is reached. When held at this point and the tape is drawn tight along the line of slope, the correction for slope is automatically made, and the front end of the tape is two chains distant horizontally. Similar graduations occur on the reverse side of the tape at the one chain marker and allow for corrections to readings as high as 80 on the abney.

Use at least 15 pounds pull on tape. When going down slopes hold trailer to prevent tape from running and piling up at bottom. Never allow a tape to remain wet over night. Dry and oil as soon as possible. Keep repair kit on the job.

Equipment for Spotting

The following is a list of equipment used by each crew member while spotting.

Compassman:

1 map of forest showing location of plot

1 staff compass and staff

1 tally register

1 5 x 8 tatum holder

2 or more section plats

2 5H pencils, eraser, sandpaper for pointing pencils

On plots where tree heights are to be taken the following additional equipment is necessary:

1 abney level

1 diameter tape

1 form, Tree Heights on Permanent Sample Plots

Spotters:

1 5 x 8 tatum holder

3 or more spotting records

2 pieces lumber caryon--blue or black

1 4H pencil and eraser

1 indelible pencil

1 2 1/2 lb. boy's axe 1 axe stone

1 Biltmore stick 1 diameter tape

1 10-inch increment borer and receptacle for cores--usually a Prince Albert tobacco can

Equipment for Cruising

The following is a list of equipment used by each crew member while making a 10 percent cruise.

Compassman

Compass and staff

Tally register

Abney level

Diameter tape

2 1/2 chain tape

1 tape repair kit

1 5 x 8 tatum holder

1 or more forms, Tree Heights on Permanent Sample Plots

1 3-H pencil, stub and eraser

Cruiser

1 Biltmore stick

1 Diameter tape

Estimator

1 5 x 8 tatum holder

2 or more Tree Class Tally forms

1 3-H pencil, eraser and stub

Working Equipment

1 staff compass and mounting and case

1 box compass

1 Jacob staff

1 abney level

2 tally registers

2 Biltmore sticks

3 diameter tapes

1 2 1/2 chain topographic tape

1 tape repair kit

3 5 x 8 tatum holders

2 increment borers

2 tree class calculators

3 1-quart belt canteens

1 2-gallon canteen

3 spotting axes

1 office box

1 truck, tools and chains

Credit cards and truck record book

Camping Equipment

2 tents, 8x10, 10x12

1 folding table

2 folding benches

3 canvas cots

3 mattresses

1 Lang camp stove and pipe

1 6-man cooking outfit and box

2 grub boxes

1 gas lantern and box, also 1 dozen mantels, 1 generator

1 1-gallon gas can

1 No. 0 Baldwin Eagle shovel

1 3 1/2 lb. D.B. axe

1 10-inch file

1 axe stone

1 medical kit

Office Equipment

1 set survey instructions

1 set of maps of forests showing location of plots

1 survey manual

1 Insect Enemies of Western Forests

Plot envelopes with plot instruction and plot summary sheet

Forms

60 section plats

160 spotting records

20 tree height

6 plot and physical description

12 tree class tally

6 summary of tree class tally

12 sheets graph paper

24 time slips

Pencils and pen

3 5-H pencils

6 3-H

3 indelible

6 keel

1 penholder and half a dozen assorted points

9 wedge erasers for pencil tips

6 pencil clips

1 small bottle ink

2 blotters

Forms used on Survey

	Page
Plot Description	63
Summary of Sample Plot Data	64
Section Plat	65
Spotting Record	66
Plot and Physical Descriptions	67
Tree Class Tally	68
Summary of Tree Class Data	69
Tree Heights	70
Height Curve	71
Standard Height Curves	72

PLOT DESCRIPTION

Forest: FREMONT | Area: SILVER LAKE | Unit: Embody

Plot: Rock Butte | T. 28S R. 12E Sec. 18S/2 | Site 4 Table 4-4

Drainage: | Nearest P.O.: Silver Lake | County: Lake Oregon

Date est.: Oct. 1939 | Compass Declination N 21° E | Local attraction: None

INSTRUCTIONS FOR REACHING PLOT

Directions: From Fremont Highway turn left on road to Bear Flat and Klamath Agency. From highway go west about 16.5 miles. Turn right on road to Sellers Marsh; .6 mi. farther turn right on Antelope Mtn. road; 1.2 mi. farther turn left and continue .5 mile to marker on right side of road (X on tree). SW corner of plot is about 2 tallies west of road.

Dist. ranger: Rogers

Camping place: Silver Lake R. S.

Springs:

Accommodations: P.O. Store Hotel Restaurant at Silver Lake

SUMMARY OF SAMPLE PLOT DATA

FOREST Fremont AREA Silver Lake

UNIT Embody PLOT Rock Butte NO.

T. 28S R. 12E SEC. 18 1/2 M. W ACRES 320

Spotting Crew Seymour Austin Grant Date 9-13-41

NEW LOSS (Year)

Brood	Groups: No. of Groups	Groups: Av. Size	Groups: No. Trees in groups	Singles	Total No. Trees
S	3	3	9	9	18
W	5	4	20	6	26
Total	8	7	29	15	44

No. Trees Green ____ Total Trees per Sec. 88

No. Trees Colored ____ Estimating Factor 54.5

Total ____ Estimated Total 161

Percent Colored ____ Map Color ____

RED TOPS

Year	Newly Marked	Previously Marked	Unmarked	Total
19 40	20	26		46
19				
19				
19				
19				
Unknown Year				
TOTAL				

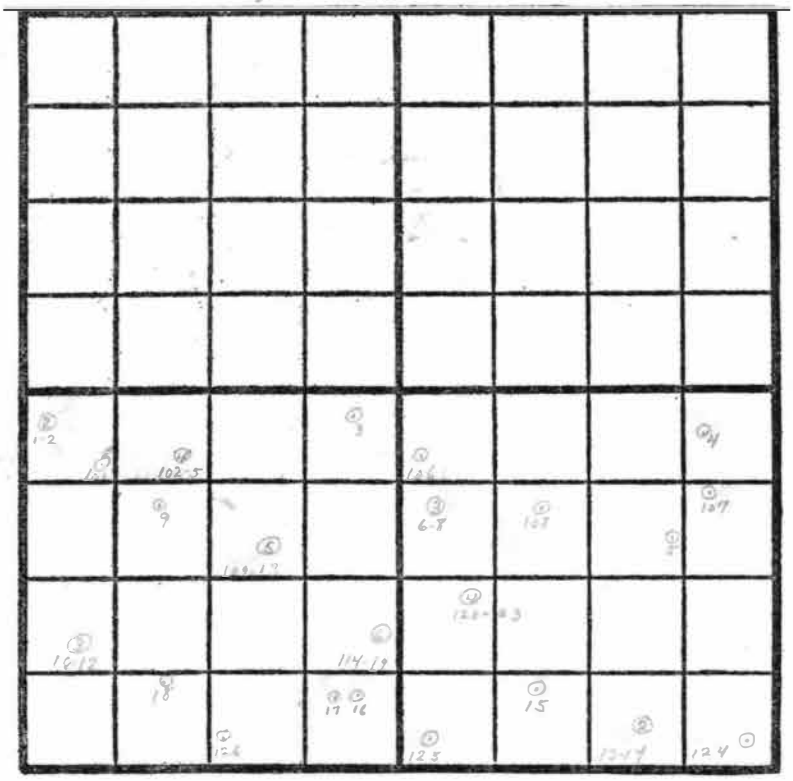
Forest - Fremont

SECTION PLAT

Project area Silver Lake *Unit* Embody

Date 9-13-41 *T.* 22 S. *R.* 12 E. *Sec.* 17 S ½

Compassman Seymour *¼ Sec.* .....



Timbered acreage .....

Percentage by species .....

Volume B. F. per acre .....

Character of timber stand .....

Topography .....

General slope and exposure .....

Remarks: 1941 Loss

	Trees	Volume
S	17	13 500
W	26	19 500
Total	44	33 000

Form EQ-37
Revised Feb. 15, 1936

U. S. GOVERNMENT PRINTING OFFICE 8—11440

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

Forest - Fremont

SPOTTING RECORD

Project area Silver Lake Unit Emigrant Camp No. Plot Rock Butte

Date 9-13-41 Spotter Grant T. 28S R. 12E Sec. 18 S½

Tree No.	Killed by	D B H	Logs	Volume	Species		Tree Class	Remarks
1	DB	28		105	S		3-c	
2	DB	36		203	S		4-b	
3	FH	20		36	S		3-c	
4	FH	44		328	S		4-b	
5	DM	28		105	W		3-c	
6	DB	34		176	S		4-c	
7	DB	16		17	S		4-d	
8	DB	10		2	S		4-d	
9	U	26		73	W		3-c	
10	DB	10		2	W		3-d	
11	DB	38		232	W		3-b	
12	DB	32		152	W		3-c	
13	DB	48		390	S		4-b	
14	DB	28		105	S		4-c	
15	DV	34		176	S		4-d	
16	DM	28		105	W		3-c	
17	IO	14		11	S		1-b	
18	DM	20		36	W		2-c	
		11	S	1541				
		7	W	718				
				2259				
18 Totals,								

Form EQ-38

8—6852 U. S. GOVERNMENT PRINTING OFFICE

PLOT DESCRIPTION - REGIONAL FOREST INSECT SURVEY

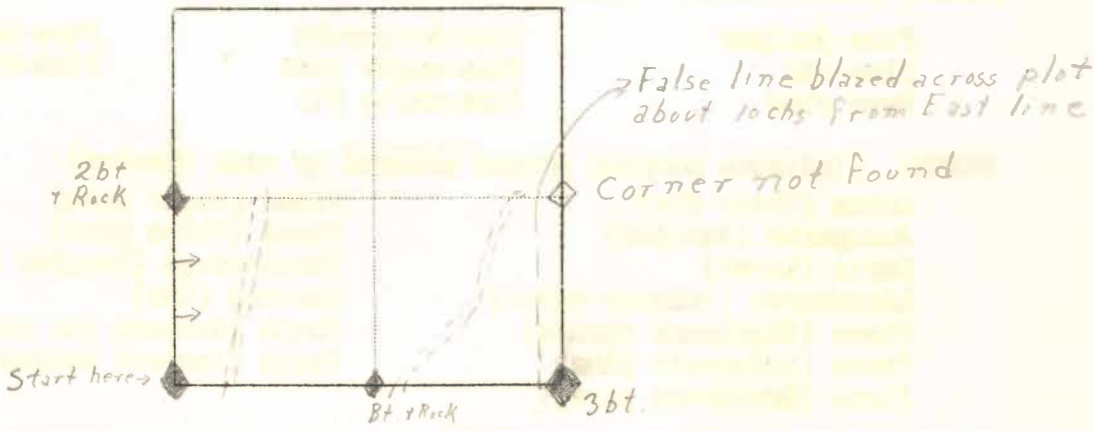
FOREST Fremont AREA Silver Lake UNIT Embody

NAME OF PLOT Rock Butte T. 21S R. 12 E Sec. 18S½ M. W Plot No. ____

Drainage Silver Lake Nearest P. O. Silver Lake County Lake State Oregon

Date established 8-14-41 Years cruised 1 Date 9-12-42

Corners (West) SKETCH Corners (East)



(Indicate starting point and direction of cruise by arrows)

COMPASS: Declination 21° Local attraction None

INSTRUCTIONS FOR REACHING PLOT

(Give road directions, names of local rangers or others familiar with location, location of good camping place, location of springs, best available hotel or restaurant accommodations, etc.)

From Fremont Highway turn left on Bear Flat-Klamath Agency road; go west 16.5 miles; turn right on road to Sellers Marsh; go 0.6 mile north and turn right on Antelope Mt. road. Go 1.2 miles, turn left and continue 0.5 mile to marker on right side of road (X on 30" ppine) SW corner of plot 2 tallies west of marker

PHYSICAL DESCRIPTION

ACREAGE: Timbered 280 Cut 0 Burned 0 Open 40 Total 320

TOPOGRAPHY: Elevation 5000' General Features Rolling

SOIL: Origin Volcanic General Character Pumice and rock outcroppings

PLANT INDICATORS

FOREST ASSOCIATIONS: (Check one only)

Pine-juniper	Pine-lodgepole	Pine-Douglas fir
Pine-oak	Pine-sugar pine	Pine-larch
Pure pine ✓	Pine-white fir	

TREES: (Indicate percent ground covered by each species)

Abies (White fir) 1%	Pinus (Sugar pine)
Juniperus (Juniper)	Pinus (White pine)
Larix (Larch)	Pseudotsuga (Douglas fir)
Libocedrus (Incense cedar)	Quercus (Oak)
Picea (Engelmann spruce)	Thuja (Western red cedar)
Pinus (Lodgepole pine)	Tsuga (Western hemlock)
Pinus (Ponderosa pine) 99%	

SHRUBS: (Check all noted on plot)

Amelanchier (Service berry)	Prunus (Choke cherry)
Arctostaphylos (Manzanita) ✓	Prunus (Wild plum)
Artemesia (Sagebrush)	Purshia (Bitter brush) ✓
Castonopsis (Chinquapin)	Rhamnus (Cascara)
Ceanothus (Snow brush)	Rhus (Poison oak)
Ceanothus (Squaw carpet)	Ribes (Gooseberry)
Cercocarpus (Mountain mahogany) ✓	Ribes (Currant)
Corylus (Hazel)	Rosa (Wild rose)
Holodiscus (Cream bush)	Rubus (Thimbleberry)
Lonicera (Honeysuckle)	Sambucus (Elderberry)
Prunus (Bitter cherry)	Symphorocarpus (Snow berry)

FOREST CONDITIONS: Forest Type 20.5 Site Class IV-

Reproduction P. Pine Density 30%

Ground cover Manzanita Density 60%

Fire injury None Last fire 1870

Remarks: (Note cuttings, windfalls, fires, or other abnormal conditions that might affect interpretation of plot data)

Beetle control done in 1940

TREE CLASS TALLY

Forest Fremont Area Silver Lake Unit Embody
Plot Rock Butte Site 4 T. 27S R. 12E Sec. 15 Forty SW¼ SW¼
Cruiser Grant Date 7-14-41 Cruise 10 percent Acres 16

DBH Saplings	1				2				3				4				TOTAL
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	
10																	33
12																	51
14																	46
16																	33
18																	34
20																	38
22																	32
24																	32
26																	20
28																	16
30																	17
32																	24
34																	10
36																	10
38																	8
40																	1
42																	3
44																	
46																	1
48																	
50																	
	57	39	20	2	21	40	34	17	17	34	29	15	17	37	22	8	409

Form EQ-220

8—13154 U. S. GOVERNMENT PRINTING OFFICE

SUMMARY OF TREE CLASS TALLY

Forest Fremont Area Silverlake Unit Embody Plot Rock Butte

Site 4 Acres 320 Cruise % 10 T. 28 R. 12 Sec. 18 S ½ Subdiv.

Cruisers Grant Austin Seymour Date 8-14-41

DBH	1 A	1 B	1 C	1 D	2 A	2 B	2 C	2 D	3 A	3 B	3 C	3 D	4 A	4 B	4 C	4 D	TOTALS Snag	TOTALS
●	6 12	9 18	11 22	1 2				6 12										33 66
12	12 60	16 80	7 35	1 5			5 25	7 35				3 36						51 276
14	10 120	8 88	1 11			1 11	13 143	4 44				9 108						46 525
16	11 187	2 34	1 17			5 85	7 119	1 17			1 18	2 36				3 54		33 567
18	6 150	2 50			1 25	13 325	5 125			1 27	5 135	1 27						34 864
20	8 288	1 36			7 252	10 360	2 72			2 76	7 266					1 38	2	38 1388
22	3 144				2 96	9 432	1 48		1 52	8 416	4 208			1 52	1 52	2 104		32 1604
24	1 64				6 384	2 128	1 64			8 544	8 544			2 136	3 204	2 136	1	32 2204
26					4 320				3 258	4 344				4 344	4 344		2	20 1610
28					1 100				4 440	5 550	1 110			2 220	3 330		3	16 1750
30									4 540	3 405	3 405			4 540	3 405			17 2295
32									3 486	3 486			5 820	11 1782	2 324		3	24 3898
34									2 380				1 190	4 756	3 570		2	10 1896
36													4 872	5 1090	1 218		2	10 2180
38													5 1250	1 250	2 500		1	8 2000
40														1 284				1 284
42													2 676	1 318				3 994
●																		
46														1 389				1 389
48																		
50																		
Total	57 1025	38 306	20 83	2 7	21 1129	40 1341	34 596	18 167	17 2156	34 2846	29 1476	15 207	17 3787	33 6161	22 2949	5 332		409 19990
																		Scribner Decimal C

Form EQ-221

U. S. GOVERNMENT PRINTING OFFICE 8—13051

Tree Heights on Permanent Sample Plot

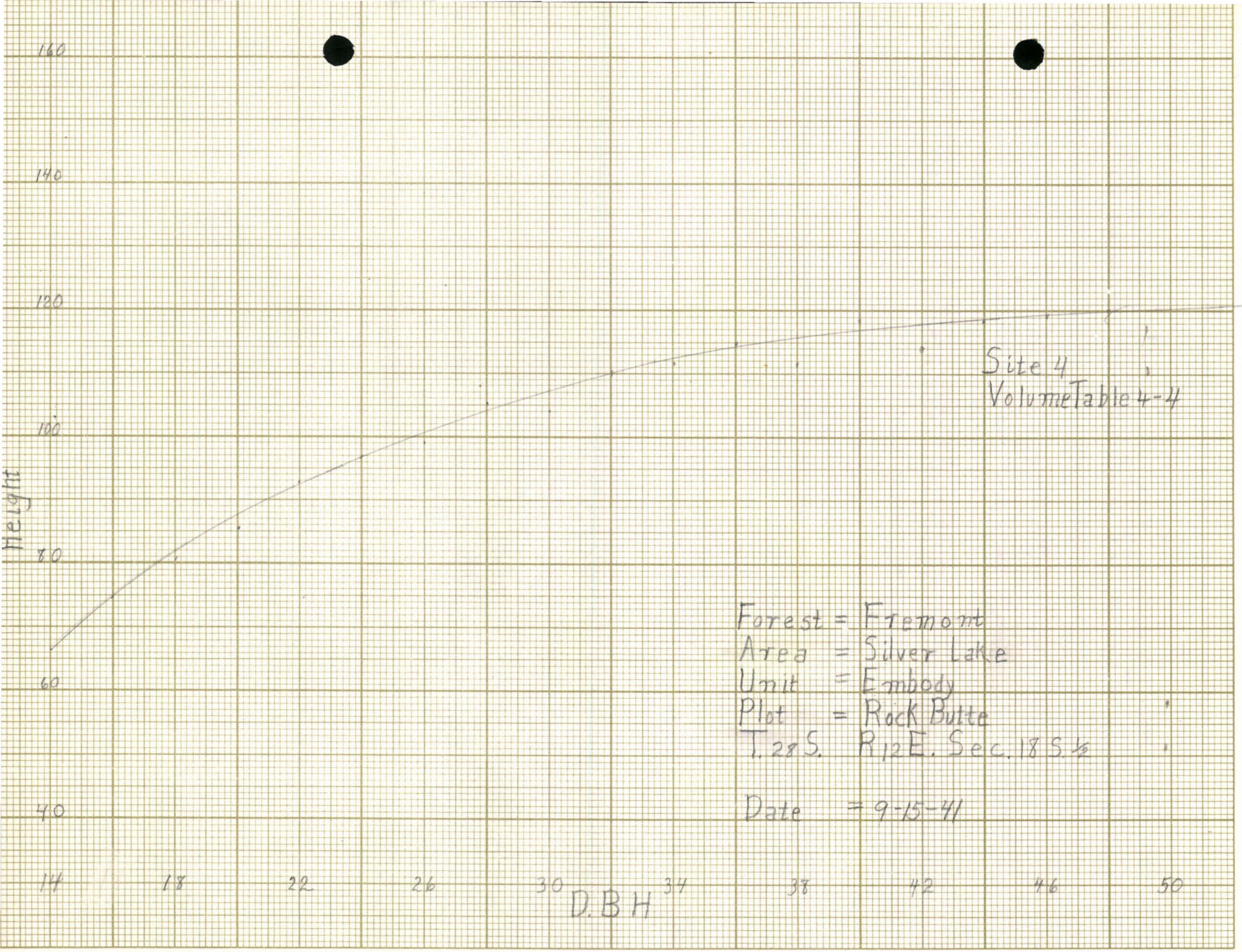
Forest Fremont Area Silver Lake Unit Embody

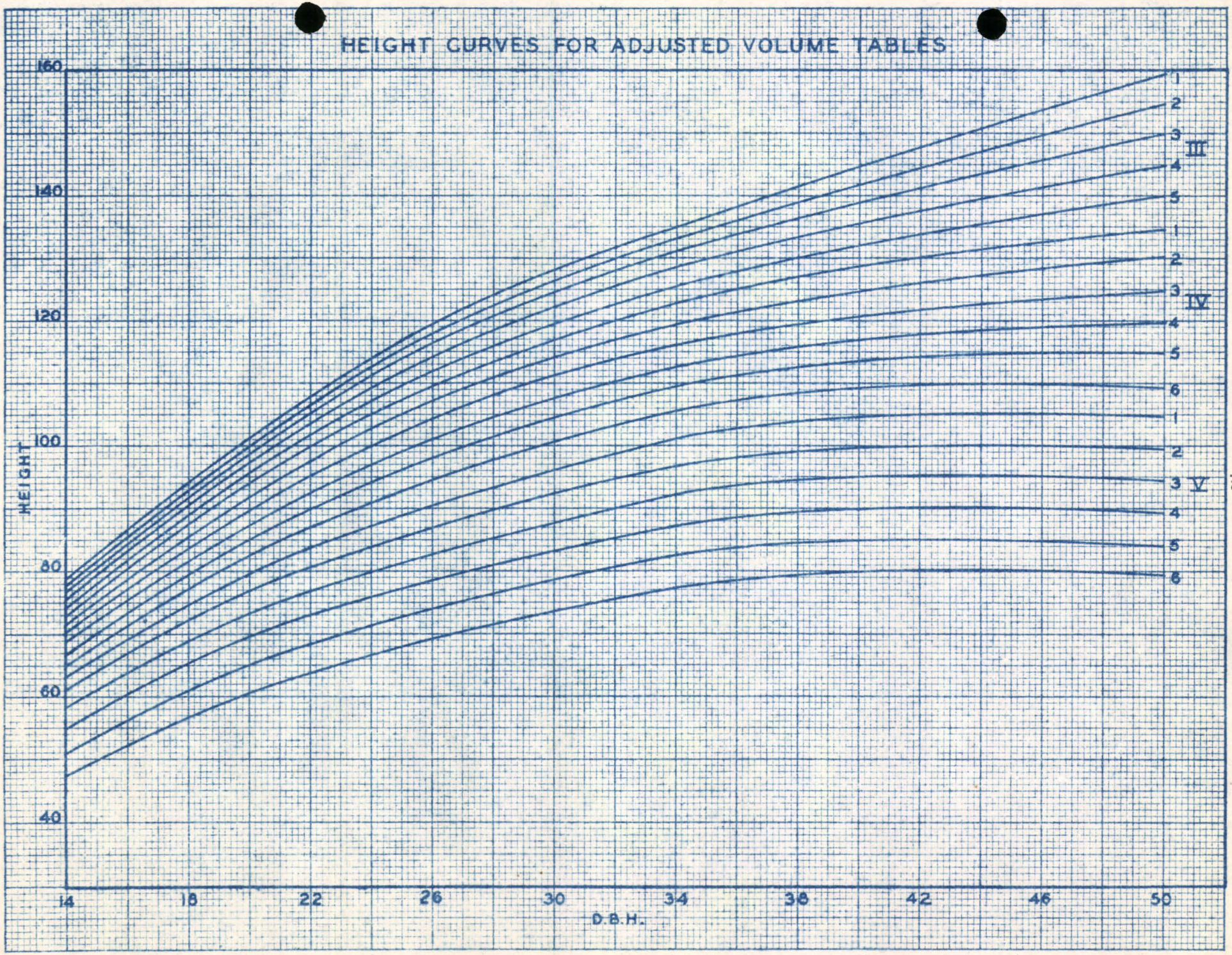
Plot Rock Butte T. 28 S R. 12 E Sec. 18 S½

Cruiser D.B. Austin Date 9-15-41

D.B.H.	¼ Sec. SE		¼ Sec. SW	
	~~Class 1 and 2~~	~~Class 3 and 4~~	~~Class 1 and 2~~	~~Class 3 and 4~~ Average
10	48 (48 36 46)		40 48 44	44 44
12	62 54 58	58	48 60 64 54	57
14	72 66 67 64 62	66	74 62 69	68 67
16	70 80 73	75	79 71 69 86	76 75
18	80 89 70 88 74	81	86 78 79	81 81
20	81 78 83 80	83	92 89 84 88	88 86
22	101 110 80 96	97	90 89 99 79	89 93
24	89 110 90 106	99	94 86 108 95	96 97
26	112 84 92 96	96	94 108 110 86	99 98
28	112 100 106 101	105	90 108 116	105 105
30	86 106 98 115	101	110 101 113 98	107 104
32	115 110 112	112	110 114 100	108 110
34	121 107 117 115	115	101 133 95 120	110 112
36	110 117 112	113	108 110 120	113 113
38	130 101 120 95	111	117 105 110 121 99	111 111
40	105 121 118 126	117	110 128 117 124	120 118
42	110 119 99 122	112	126 100 118	115 114
44	95 128 120	114	108 130 127	121 118
46	115 112 120	116	122 122	122 119
48	121	121	110 128	119 120
50				
52				
Total No. 2 Heights				

Form P.S.10


160
140
120
100
80
60
40
Height
14
18
22
26
30
34
38
42
46
50
D.B.H.
Site 4
Volume Table 4-4
Forest = Fremont
Area = Silver Lake
Unit = Embody
Plot = Rock Butte
T. 28 S. R 12 E. Sec. 18 S ½
Date = 9-15-41


HEIGHT CURVES FOR ADJUSTED VOLUME TABLES
160
140
120
100
80
60
40
HEIGHT
14
18
22
26
30
34
38
42
46
50
D.B.H.
III
IV
V
1
2
3
4
5
1
2
3
4
5
6
1
2
3
4
5
6

VIII. APPENDIX

Keen Tree Classification

The Keen Tree Classification is to be applied to all dead trees marked by spotters and green trees from which increment cores are taken, also all green ponderosa pine recorded in making a 10 percent inventory cruise. See attached copy, "Ponderosa Pine Tree Classes Redefined."

Tree Class Calculator

See attached copy

Correction Factor for Time of Survey

As only a portion of the total loss for the season has been attacked by the time of survey, the probable total for the season may be estimated by employing an estimating factor developed from past surveys as to the probable percent of the total season's loss spotted on any one date. These factors are shown on the attached table and graph.

Volume Tables

Attached.

UNITED STATES DEPARTMENT OF AGRICULTURE
Bureau of Entomology and Plant Quarantine
Division of Forest Insect Investigations

Portland, Oregon February 10, 1941

Extracts from Report
PONDEROSA PINE TREE CLASSES REDEFINED

By F. P. Keen
Senior Entomologist

The ponderosa pine tree classification developed by the writer[1] for determining susceptibility of ponderosa pines to bark beetle attack has been used in this region for timber-marking purposes and for insect mortality and growth studies during the past 4 years. It has also been adapted by Hornibrook[2] to fit conditions found in the Black Hills of South Dakota and Wyoming and by Thomson[3] for application in the Southwest. In practical field use the need has arisen for more exact definitions and a weighting of the more important factors, in order to obtain closer standardizing of interpretation and to iron out such ambiguities as existed in the original descriptions.

Following a recent study of 3,700 trees as to growth rates, crown characteristics, and susceptibility to bark beetle attack, new definitions have been prepared. Whereas no change has been made in the average criteria for any tree class, these new definitions should make possible an improvement in the classification of borderline trees so as to place them in the class most nearly representing their respective growth rate and mortality risk. The revised descriptions of the tree classes are as follows:

1/ Keen, F. P. 1936. Relative susceptibility of ponderosa pines to bark-beetle attack. Jour. Forestry 34: 919-927, illus. Oct.

2/ Hornibrook, E. M. 1939. A modified tree classification for use in growth studies and timber marking in Black Hills ponderosa pine. Jour. Forestry 37: 483-488, illus. June.

3/ Thomson, Walter G. 1940. A growth rate classification of southwestern ponderosa pine. Jour. Forestry 38: 547-553, illus. July.

REVISED DESCRIPTION OF TREE CLASSES

The two primary factors on which this tree classification is based are age and crown vigor. Each of these factors is subdivided into four parts, making a total of 16 tree classes. Although four age groups and four crown-vigor subdivisions can be recognized in any ponderosa pine stand, the tree characteristics which differentiate the age or vigor groups vary considerably in different parts of the pine region and on different sites, and hence cannot be described specifically, except for a particular site and for limited portions of the region. Thus the following descriptions apply primarily to average Site IV in central and southern Oregon and northeastern California. Hornibrook has given the corresponding descriptions for the Black Hills ponderosa pine, and Thomson has described the characteristics of similar age and vigor groups in the Southwest. Other modifications will be needed to fit conditions in other regions, but the general principles are the same anywhere.

AGE CLASSES

Trees are first divided into four age groups--young, immature, mature, and overmature. The purpose here is to recognize relative maturity or "physiological age" rather than any definite age limits as shown by the number of annual rings. Differences in site, moisture, elevation, and other environmental factors influence the age at which trees reach maturity in different parts of the ponderosa pine region. The tendency is for trees to reach maturity earlier on poor sites than on good sites.

The external characters most valuable as indicators of maturity are the color and character of the bark, the total height of the tree, shape of the top, character of branches and branching, and diameter. These characters for Site IV in the ponderosa pine stands of central and southern Oregon and northeastern California are given below and in table 1.

Age Class 1.--Young trees. Commonly referred to as "bull pines" or "black jacks"; thrifty trees making rapid height and diameter growth; age usually less than 80 years.

D.b.h.--Rarely over 20 inches.

Height.--In lower crown canopy usually less than 60 percent of total mature height.

Bark.--Dark, grayish brown to black; rough, and deeply furrowed without plates, but with narrow ridges between the fissures (sometimes coloring at extreme base).

Branches.--Upturned and in whorls for upper three-fourths of crown; small for diameter of bole.

Top.--Usually pointed, with distinct whorls.

Age Class 2.--Immature trees; still making rapid height and diameter growth in thrifty trees; age approximately 80 to 180 years.

D.b.h.--Rarely over 30 inches.

Height.--Usually less than 90 percent of total height at maturity. Trees still under the general crown canopy.

Bark.--Dark reddish brown, with narrow, smooth plates between fissures on lower half of bole; dark, rough bark on upper half.

Branches.--Mostly upturned and in whorls for upper half of crown; horizontal near middle, horizontal or drooping below; small to medium size for diameter of bole.

Top.--Usually pointed, sometimes rounded, but with whorls indistinct.

Age Class 3.--Mature trees. Height growth practically complete; diameter growth slow; age approximately 180 to 300 years.

D.b.h.--Rarely over 40 inches.

Height.--Practically that of the general crown canopy; except intermediate, suppressed or top-killed trees.

Bark.--Light reddish brown with moderately large plates between the fissures on lower three-fourths of bole; dark bark showing in upper quarter.

Branches.--Upturned near top, middle crown horizontal, lower ones drooping; moderately large for size of bole.

Top.--Usually pyramidal or rounded, occasionally pointed; whorls indistinct except at extreme top.

Age Class 4.--Over-mature trees. Making no further height growth; diameter growth very slow; age more than 300 years.

D.b.h.--Wide latitude in diameters, but usually large in dominant trees.

Height.--Full height of general crown canopy, except suppressed, spike-topped or broken trees.

Bark.--Light yellow and uniform for entire bole, except in extreme top; plates usually very wide, long, and smooth; fissures often rather shallow.

Branches.--Large, heavy limbs, often gnarled or crooked; mostly drooping except in extreme top.

Top.--Usually flat; occasionally rounded or irregular.

The distinction between age classes 1 and 2 is based largely on color and roughness of bark as well as character of branching. While both are sometimes called "bull pines" or "black jacks", only class-1 trees have the rough, black bark for practically the entire length of the bole, and upturned branches in distinct whorls, so characteristic of young, juvenile growth. Class-2 trees have this dark, rough bark in the upper half of the bole, but the bark on the lower half is turning red and developing narrow plates on the ridges, particularly on the south side.

The distinction between age classes 2 and 3 is mainly a matter of height, character of the bark, and branching in the upper part of the tree. Class-2 trees are understory trees somewhat less than 90 percent of the height of the general crown canopy, whereas class-3 trees have practically reached the height of the general crown canopy and only show dark bark and upturned branches in the upper quarter of the crown.

The distinction between age classes 3 and 4 is more difficult to recognize, since there is no sharp line of demarcation between a mature and an overmature tree. Light colored bark for practically the entire bole, absence of dark bark on the bole except at the extreme top, and large heavy limbs, mostly horizontal or drooping, are the principal distinguishing features of overmaturity.

In the field, age classes of dominant and codominant trees are fairly distinctive. Suppressed and intermediate trees in the older-age classes often cause more difficulty, since their diameters are small and they frequently simulate the characters of younger trees. Since ponderosa pine usually grows in even-aged groups, the age class of the surrounding trees will usually give a clue to the age of suppressed individuals in the group.

CROWN-VIGOR CLASSES

It is a well-recognized silvicultural principle that the growth rate of trees for a given site and age class is directly proportional to the size of crown or area of leaf surface.[4/] Therefore in this classification each age class is subdivided into four divisions based on size of crown and abundance of foliage. These subdivisions, grouping together trees of similar growth capacities, indicate four degrees of relative crown vigor and are designated A, B, C, and D from best to poorest.

In the study of growth rate of trees in relation to crown characteristics, the following factors, in order of their importance, were found to be the best outward indicators of crown vigor and inherent growth capacity:

(1) Size of crown--length, width, and circumference.
(2) Density of crown.
(3) Form of top--pointed, round, flat, or spiked.
(4) Location of crown on the bole.
(5) Position of tree--isolated, dominant, codominant, intermediate, or suppressed.

Apparently in uneven-aged stands, such as open-grown ponderosa pine, the size and density of a tree's crown usually reflects the tree's position as to dominance or light and the amount of root competition.

In defining the four crown-vigor classes, it is impossible to describe all the variations in crown shape which may be encountered. Crown size and density are the principal criteria, and typical trees of crown-class A, which might be considered as the ideal outline, may be used as a standard of comparison. In the following descriptions it should be understood that other shapes may still belong to that crown-vigor class, provided the total volume of crown comes within the established limits.

4/ Dunning, Duncan. 1922. Relation of crown size and character to rate of growth and response to cutting in western yellow pine. Jour. Forestry 20: 379-389. Apr.

The crown-vigor classes are defined below, and their descriptions are given in condensed form in table 2.

A--Full vigor

Crown.--Full vigorous crowns with a length of 55 percent or more of the total height, and of average width or wider; with density average or better for its age class.

Foliage.--Needles of average length or longer, usually dense and thrifty.

Position.--Usually isolated or dominant; rarely codominant.

D.b.h.--Large for age.

B--Good to fair vigor

Crown.--Good to moderately vigorous crowns, with length from 30 to 55 percent of total height, if of average width and density; or a longer crown if narrow or somewhat thin; but neither sparse nor ragged.

Foliage.--Needles of average length, usually dense and thrifty.

Position.--Usually codominant, but sometimes isolated or dominant; rarely intermediate.

D.b.h.--Average or above for age.

C--Fair to poor vigor

Crown.--Fair to poor crowns, with length from 10 to 30 percent of total height if of average width and density, or long, sparse, and narrow; often flat on one or more sides.

Foliage.--Needles often short and thinly distributed, but of normal length and density when confined to top one-third of crown.

Position.--Usually intermediate, sometimes codominant or suppressed, but rarely isolated.

D.b.h.--Usually below average for age; sometimes large in decadent trees.

D--Very poor vigor

Crown.--Very short, less than 10 percent of the total height; sometimes merely a tuft at top of tree, or somewhat longer when sparse and ragged; usually very narrow or limbs all on one side.

Foliage.--Needles often short, and foliage sparse or scattered, or only tufts at end of twigs; but of normal length and density if reduced in quantity.

Position.--Usually suppressed or intermediate, but may occupy other positions if greatly reduced in vigor.

D.b.h.--Decidedly subnormal for age, but very old decadent trees may be of large diameter.

Current tree health

The present tree classification is primarily concerned with the inherent vigor and growth capacity of the tree which, depending on crown size and position, changes but slowly over a period of years. However, there is another point which should be kept in mind in applying this classification, i.e., the current tree health which may change rapidly. Such changes, probably caused by deficiencies in available moisture and food supply, the debilitating effects of fire, insects, disease, or other pathological conditions are evidenced by the length and color of foliage, the number of needles per year's growth of twig and the presence of dying portions of the crown. These are indications of current tree health which can be designated by a plus (+) or minus (-) sign added to the tree class designation if the tree is currently improving or declining in vigor. The tree class designation, based on the size of the living crown, the position of the tree, and the diameter attained, thus indicates its growth capacity over a relatively long period of time. The additional appraisal of current tree health may be used to indicate the current susceptibility of individual trees to bark beetle attacks.

TABLE 1.--AGE CLASSES

Character	Class 1	Class 2	Class 3	Class 4
Maturity:	Young	Immature	Mature	Overmature
Age:	Usually less than 80 years	Approximately 80 to 180 years	Approximately 180 to 300 years	More than 300 years
D.b.h.:	Rarely over 20 inches	Rarely over 30 inches	Rarely over 40 inches	Usually large diameters in dominant trees
Height:	In lower canopy usually less than 60% of total height of mature canopy	Height usually less than 90% of total height of mature canopy	Height practically that of general crown canopy (except of intermediate, suppressed or topkilled trees)	Full height of general canopy (except suppressed, spike-topped or broken trees)
Growth and taper:	Thrifty trees making rapid height and diameter growth. Rapid taper	Considerable height growth still in progress; good diameter growth in thrifty trees. Taper considerable	Height growth practically complete; diameter growth slow. Moderate taper	Making no height growth; diameter growth very slow. Least taper
Bark color:	Dark grayish brown to black (except at extreme base)	Dark reddish brown on lower half of bole; dark bark on upper half	Light reddish brown on lower three-fourths of bole; dark bark showing in upper one-fourth of bole	Light yellow; uniform color throughout bole (except at extreme top)
Bark plates:	No plates. Rough bark, deeply furrowed, with narrow ridges between fissures	Narrow smooth plates between fissures	Moderately large plates between fissures	Plates usually very wide, long, and smooth; fissures often rather shallow
Branches	Branches upturned in upper three-fourths of crown; small for diameter of bole	Mostly upturned in upper half of crown; lower half horizontal or drooping; small to medium for diameter of bole	Upturned near top; middle horizontal; lower ones drooping; moderate for size of bole	Large, heavy limbs, often gnarled or crooked; mostly drooping, except in extreme top
Whorls:	Whorls distinct in upper crown	Whorls distinct in upper half of crown	Whorls indistinct except at extreme top of crown	Whorls indistinct and incomplete
Top:	Top usually pointed	Top usually pointed, sometimes rounded	Top usually pyramidal or rounded, sometimes pointed	Usually flat, occasionally rounded or irregular

Note: Description primarily applicable to central and southern Oregon and northern California, Site IV

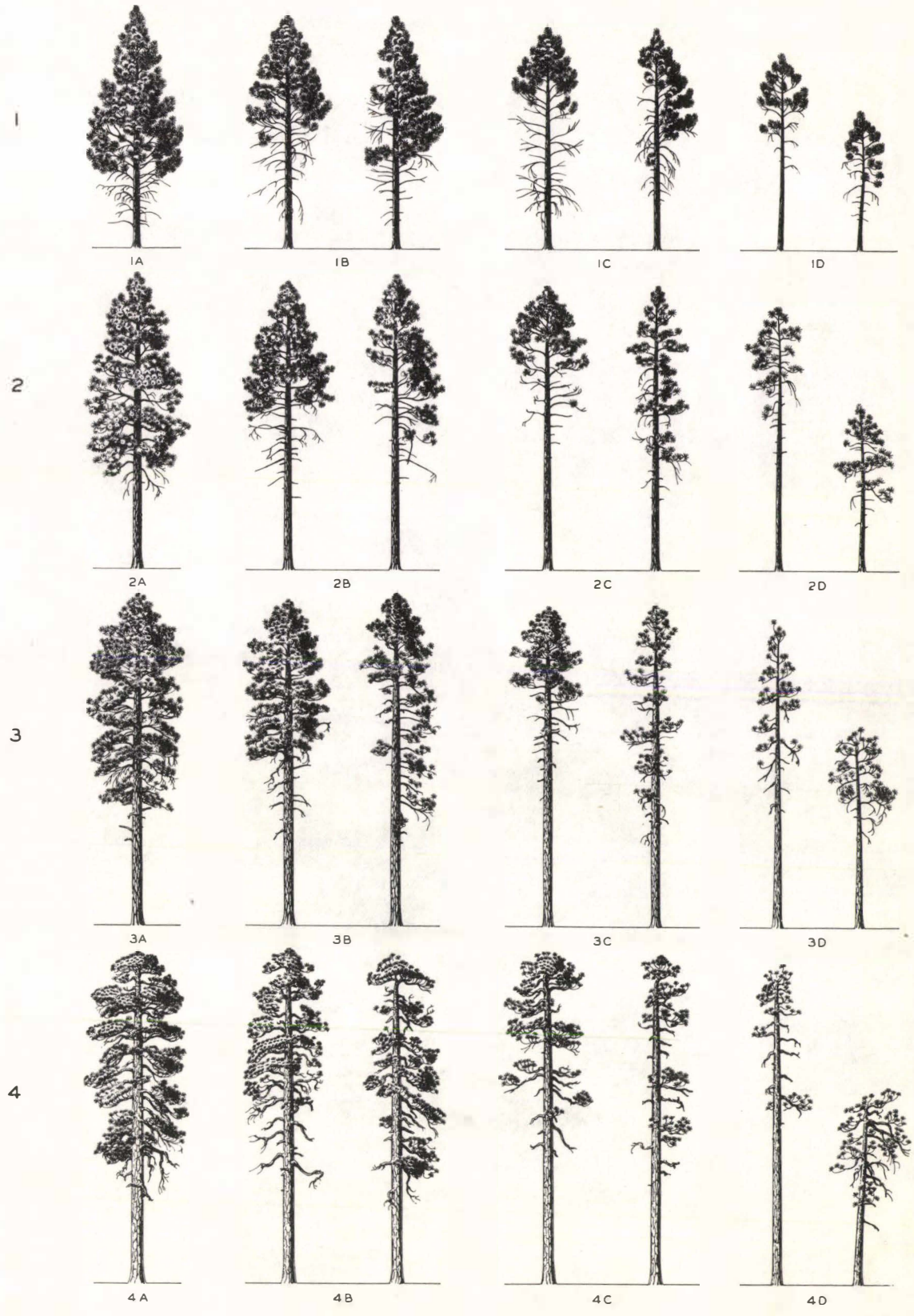
TABLE 2.--CROWN-VIGOR CLASSES

Character	Class A	Class B	Class C	Class D
Crown vigor:	Full, vigorous	Good to fair	Fair to poor	Very poor
Crown length:	Long, 55% or more of total height; or less only if more than average width	Average length, less than 55% of total height (approximately 30% to 55% if full and wide) or a longer crown if narrow or somewhat thin	Short (from 10% to 30% of height, if crown of normal density) or long, sparse, and narrow	Very short (less than 10% of total height) sometimes merely a tuft at top of tree, or somewhat longer when sparse and ragged
Crown width:	Usually average width or wider (narrower if very long and dense)	Usually average width or narrower; may be flat on one side	Usually narrow or flat on one or more sides	Usually very narrow and sparse, or limbs all on one side
Crown density:	Usually full and dense or of medium density if longer than 55%	Usually of full to medium density, not sparse or ragged	Often sparse and ragged except at very top	Sparse and ragged
Foliage:	Needles of average length or longer, usually dense and thrifty	Needles of average length, usually dense and thrifty	Needles often short and thinly distributed, but of normal length and density when confined to top one-third of crown	Needles often short; foliage sparse or scattered or only partially developed, but of normal length if reduced in quantity
Position:	Usually isolated or dominant, rarely codominant	Usually codominant; sometimes isolated or dominant; rarely intermediate	Usually intermediate; sometimes codominant or suppressed, but rarely isolated or dominant	Usually suppressed or intermediate, but may occupy other positions if greatly reduced in vigor
Diameter	Large for age	Average or above for age	Usually below average for age; sometimes larger in decadent trees	Decidedly subnormal for age, but very old, decadent trees may be of large diameter

Note: The descriptions apply to the usual types of trees found in each class; where exceptions occur, the size of living crown and amount of foliage are the primary considerations in determining the vigor class.

A PONDEROSA PINE TREE CLASSIFICATION

BASED ON AGE AND VIGOR



TREE CLASS CALCULATOR

To eliminate as far as possible the personal equation and to standardize interpretation of the various tree classes, a "tree class calculator" has been devised, which puts the essential factors of tree classification on a rule of thumb basis. The weight given to factors used in the construction of these rules was determined by a statistical analysis of the 3477 trees described on the 14 ten-acre plots. The methods of curvilinear multiple correlation described by Bruce and Reineke (8) were followed in making this analysis.

Crown Class Rule. Crown class as indicated by this slide rule is simply determined by the multiplication of relative length of crown, width of crown, and density of crown, as compared with the ideal outline of an "A" crown tree. The formulae might be written as follows:

Crown Class = L x W x D x S in which

L = Percent of crown length as compared with total height of tree. (In case of spike-top trees, the original total height of tree has to be assumed.)

W = Percent of width of crown as compared with the normal width of full-crowned "A" tree of similar height. (In trees of unsymmetrical crown, width is best taken as the radius of the widest side.)

D = Percent of density or fullness of crown as compared with normal fullness of an "A" tree. (This is best estimated by visualizing the crown pushed up the tree to fill the upper cone to normal density and then estimating what percent of total crown length would be filled.)

S = This is a correction factor (70 percent) for spike-topped or suppressed trees.

Operation of rule:

(1) Pull slide until "W" is over "Length of crown %" determined
(2) Slip runner to "Width of crown %" determined
(3) Pull slide until "D" is under cross hair of runner if tree has normal top, or use "S" if the tree is suppressed or spike topped
(4) Read crown class on upper scale above the "density of crown %" determined as applicable.

Maturity Class Rule. This rule was first computed in the form of an alinement chart from a multiple curvilinear correlation analysis of the factors involved, and then converted to slide rule form. It was found that of the several factors tested, the percent of black bark and the diameter were the most important in determining relative maturity. Slight corrections were found to be needed for the various crown classes and for sites other than Site IV.

"Black bark %" is defined as the proportion of rough black bark characteristic of rapidly growing bark on a Class 1 tree, or that on the leader of older trees. In Class 1 trees this bark covers 100 percent of the bole. In older trees only a small percent of the top shows this growing condition. In older trees, where the limits of the black bark are not easily discernible, the point where the limbs are horizontal (drooping below and upturned above) can be used instead, for a satisfactory approximation.

Operation of the rule:

If on Site IV:

(1) Pull slide until crown class letter (previously determined) is over "black bark %".
(2) Read maturity class above appropriate d.b.h.

If Site III or Site V is involved; after step (1):

(2) Slip runner to "Av."
(3) Push slide until appropriate site is under hair line of runner.
(4) Read maturity class above appropriate d.b.h.

GREEN STAND
Adjusted Volume Table - Scribner Decimal C
Site III

	Mature					Immature				
	Minus	Medium Site			Plus	Minus	Medium Site			Plus
		Table Number					Table Number			
	5	4	3	2	1	5	4	3	2	1
	Height at 50" and 30" Dbh					Height at 50" and 30" Dbh				
50"	140	145	150	155	160	140	145	150	155	160
30"	120	123	125	127	129	120	123	125	127	129
Dbh										
10	3	3	3	3	3	2	2	2	2	2
12	7	7	7	7	7	6	6	6	6	6
14	13	13	13	13	13	12	12	12	12	12
16	20	20	20	20	21	19	19	19	19	20
18	29	30	30	30	31	28	29	29	30	30
20	41	41	42	42	43	40	41	42	42	43
22	55	56	56	57	57	54	55	56	56	56
24	73	73	73	74	74	71	72	73	74	74
26	92	93	94	95	95	91	93	94	94	95
28	118	119	120	121	122	112	114	115	116	117
30	145	146	147	148	149	134	135	136	137	138
32	174	175	176	177	178					
34	205	207	208	209	210					
36	240	241	242	243	244					
38	277	279	280	281	282					
40	317	320	322	324	325					
42	355	362	368	373	378					
44	400	410	418	424	429					
46	449	460	467	473	477					
48	497	510	520	527	533					
50	542	560	577	592	607					
52	601	621	634	646	657					
54	651	674	698	720	739					
56	710	735	759	781	801					
58	770	800	829	858	886					
60	830	865	900	935	968					

GREEN STAND

Adjusted Volume Table - Scribner Decimal C

Site IV

	Mature						Immature					
	Minus		Medium Site		Plus		Minus		Medium Site		Plus	
	Table Number						Table Number					
	6	5	4	3	2	1	6	5	4	3	2	1
Dbh	Height at 50" and 30" Dbh						Height at 50" and 30" Dbh					
50"	110	115	120	125	130	135	110	115	120	125	130	135
30"	101	105	108	112	115	118						
10	2	3	3	3	3	3	2	2	2	2	2	2
12	6	6	6	7	7	7	5	5	5	5	5	5
14	11	11	12	12	12	13	9	10	11	11	11	12
16	17	18	18	19	19	20	15	16	17	18	18	19
18	26	27	27	28	28	29	23	24	25	26	27	28
20	36	37	38	40	40	41	33	34	36	38	38	40
22	49	51	52	53	54	55	44	46	48	50	52	53
24	65	66	68	69	71	72	58	61	64	66	68	70
26	83	85	86	88	90	91	73	76	80	83	86	89
28	105	108	110	113	115	117	91	96	100	104	107	111
30	127	131	135	138	141	143	108	114	119	124	128	132
32	152	157	162	166	169	172						
34	176	183	190	195	199	203						
36	203	212	218	223	229	236						
38	232	242	250	259	266	272						
40	261	274	284	295	302	311						
42	291	305	318	328	339	348						
44	323	338	353	366	380	390						
46	355	370	389	403	420	434						
48	390	410	427	446	463	480						
50	422	445	466	485	508	524						
52	458	480	503	530	552	580						
54	492	520	547	572	601	628						
56	527	555	589	620	651	680						
58	565	600	632	668	705	735						
60	601	640	676	715	756	790						
62			720	765	810							
64			760	810	860							
66			815	865	920							
68			870	925	980							
70			920	970	1020							

GREEN STAND
Adjusted Volume Table - Scribner Decimal C
Site V

	Mature						Immature					
	Minus		Medium Site		Plus		Minus		Medium Site		Plus	
	Table Number						Table Number					
	6	5	4	3	2	1	6	5	4	3	2	1
	Height at 50" and 30" Dbh						Height at 50" and 30" Dbh					
50"	80	85	90	95	100	105	80	85	90	95	100	105
30"	74	79	84	88	92	96	74	79	84	88	92	96
Dbh												
10	1	2	2	2	2	2	1	1	1	1	1	1
12	3	3	4	5	5	5	2	3	4	4	4	4
14	6	6	7	8	9	10	5	6	7	7	8	9
16	9	10	12	14	15	16	8	10	12	13	14	15
18	14	17	19	21	23	24	14	16	18	20	21	22
20	22	25	28	31	33	35	21	23	25	27	29	31
22	31	35	39	42	45	47	30	33	36	38	40	42
24	41	46	51	55	59	62	39	43	46	49	52	55
26	53	59	65	71	75	80	49	53	57	61	65	69
28	67	74	81	87	93	99	61	66	71	76	81	86
30	83	93	100	108	116	122	74	80	86	92	97	103
32	101	112	121	130	137	144						
34	119	129	141	152	160	168						
36	137	148	163	174	184	193						
38	154	169	185	197	209	221						
40	172	189	207	222	235	249						
42	189	209	227	246	259	275						
44	208	230	250	270	286	304						
46	227	251	272	294	313	333						
48	248	272	296	320	340	364						
50	268	296	320	347	369	396						
52	288	317	345	372	397	427						
54	309	340	371	400	428	459						
56	330	363	397	427	460	490						
58	353	388	425	459	492	527						
60	374	411	451	487	523	560						

INSECT-KILLED TREES
Adjusted Volume Table - Scribner Decimal C
Site III

	Table Number				
	Minus	Medium Site			Plus
	5	4	3	2	1
Dbh					
10	3	3	3	3	3
12	7	7	7	7	7
14	13	13	13	13	13
16	20	20	20	20	20
18	29	29	30	30	30
20	41	41	41	42	42
22	55	55	56	56	57
24	72	73	73	73	74
26	91	92	93	94	95
28	117	118	119	120	121
30	143	145	146	147	148
32	172	174	175	176	177
34	203	205	207	208	209
36	236	240	241	242	243
38	272	277	279	280	281
40	311	317	320	322	324
42	348	355	362	368	373
44	390	400	410	418	424
46	434	449	460	467	473
48	480	497	510	520	527
50	524	542	560	577	592
52	580	601	621	634	646
54	628	651	674	698	720
56	680	710	735	759	781
58	735	770	800	829	858
60	790	830	865	900	935

Adjusted Volume Table - Scribner Decimal C
Site IV

	Table Number					
	Minus		Medium Site		Plus	
	6	5	4	3	2	1
Dbh						
10	2	2	2	3	3	3
12	5	5	6	6	6	7
14	9	10	11	11	12	12
16	15	16	17	18	18	19
18	23	24	26	27	27	28
20	33	35	36	37	38	40
22	45	47	49	51	52	53
24	59	62	65	66	68	69
26	75	80	83	85	86	88
28	93	99	105	108	110	113
30	116	122	127	131	135	138
32	137	144	152	157	162	166
34	160	168	176	183	190	195
36	184	193	203	212	218	223
38	209	221	232	242	250	259
40	235	249	261	274	284	295
42	259	275	291	305	318	328
44	286	304	323	338	353	366
46	313	333	355	370	389	403
48	340	364	390	410	427	446
50	369	396	422	445	466	485
52	397	427	458	480	503	530
54	428	459	492	520	547	572
56	460	490	527	555	589	620
58	492	527	565	600	632	668
60	523	560	601	640	676	715
62					720	765
64					760	810
66					815	865
68					870	925
70					920	970

INSECT-KILLED TREES
Adjusted Volume Table - Scribner Decimal C
Site V

	Table Number					
	Minus		Medium Site		Plus	
	6	5	4	3	2	1
Dbh						
10	1	1	1	1	2	2
12	2	2	3	3	3	4
14	4	5	5	6	6	7
16	6	7	8	9	10	12
18	8	10	12	14	17	19
20	13	16	19	22	25	28
22	22	25	28	31	35	39
24	30	33	37	41	46	51
26	40	44	48	53	59	65
28	51	56	61	67	74	81
30	67	72	77	83	93	100
32	81	87	94	101	112	121
34	91	100	109	119	129	141
36	103	113	124	137	148	163
38	118	129	141	154	169	185
40	131	143	157	172	189	207
42	147	160	174	189	209	227
44	162	176	191	208	230	250
46	179	194	210	227	251	272
48	193	210	228	248	272	296
50	212	230	248	268	296	320
52	222	242	264	288	317	345
54	238	260	283	309	340	371
56	252	276	302	330	363	397
58	268	294	322	353	388	425
60	284	311	341	374	411	451

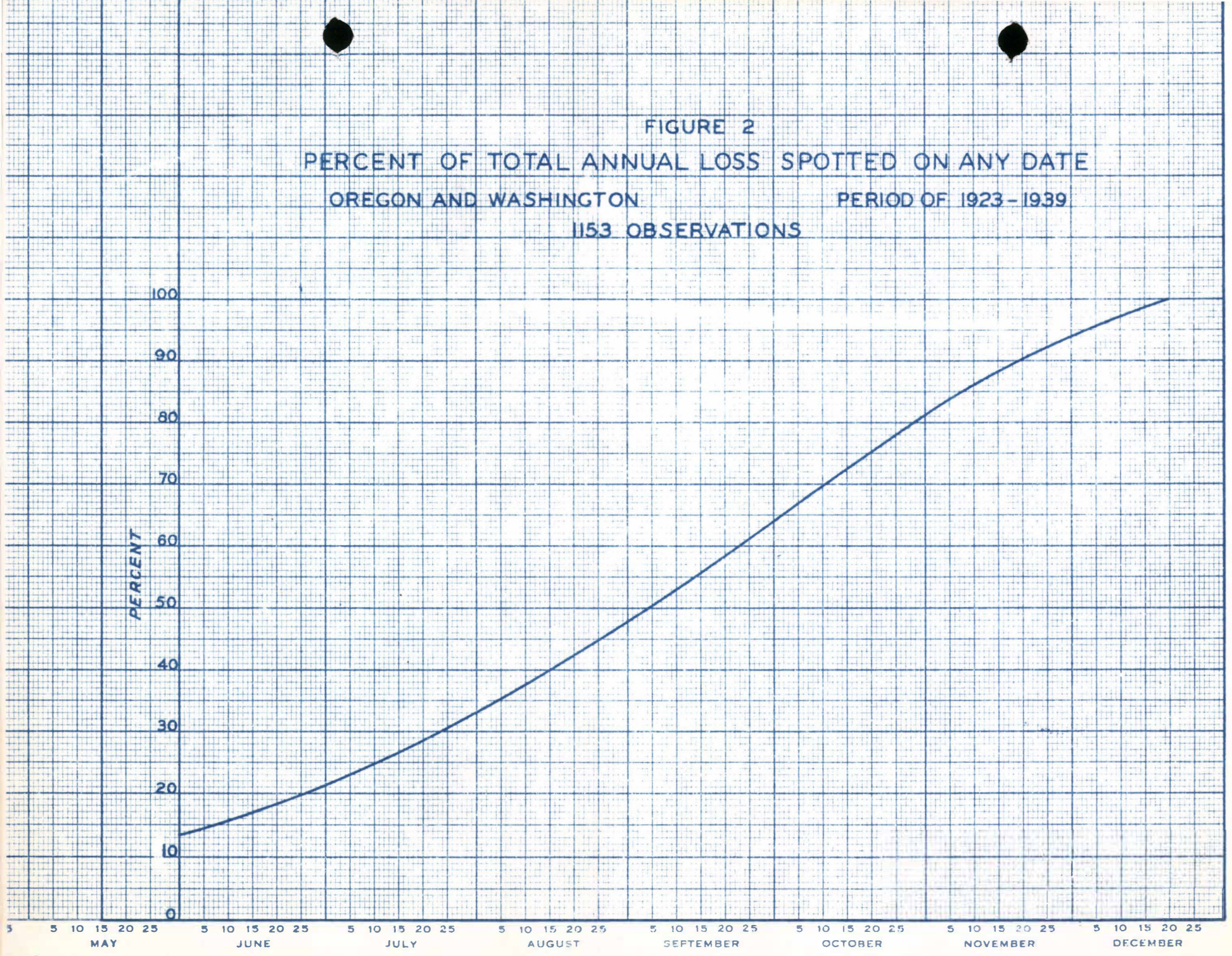
ESTIMATING FACTOR
PERCENT OF TOTAL ANNUAL LOSS SPOTTED ON ANY DATE

Grant's Curve - 1941

	July (7)	Aug. (8)		Sept. (9)	Oct. (10)		Nov. (11)	Dec. (12)
Day	%	%	Day	%	%	Day	%	%
1	21	33.5	1	48.5	64.5	1	81.5	94.5
2	21.5	34	2	49	65	2	82	94.5
3	22	34.5	3	49.5	65.5	3	82.5	95
4	22.5	35	4	50	66	4	83	95
5	23	35.5	5	50.5	67	5	83.5	95.5
6	23.5	36	6	51	67.5	6	84	96
7	24	36	7	51.5	68	7	84.5	96.5
8	24	36.5	8	52	68.5	8	85	96.5
9	24.5	37	9	52.5	69	9	85.5	97
10	25	37.5	10	53	69.5	10	86	97
11	25	38	11	53.5	70	11	86.5	97.5
12	25.5	38.5	12	54	70.5	12	87	97.5
13	26	39	13	54.5	71	13	87.5	98
14	26	39.5	14	55	72	14	87.5	98.5
15	26.5	40	15	55.5	72.5	15	88	98.5
16	27	40.5	16	56	73	16	88.5	99
17	27.5	41	17	57	73.5	17	89	99
18	28	41.5	18	57.5	74	18	89.5	99.5
19	28	42	19	58	74.5	19	90	99.5
20	28.5	42.5	20	58.5	75	20	90	100
21	29	43	21	59	75.5	21	90.5	
22	29.5	43.5	22	59.5	76	22	91	
23	30	44	23	60	77	23	91.5	
24	30	44.5	24	60.5	77.5	24	92	
25	30.5	45	25	61	78	25	92	
26	31	45.5	26	61.5	78.5	26	92.5	
27	31.5	46	27	62	79	27	93	
28	32	46.5	28	62.5	79.5	28	93.5	
29	32.5	47	29	63	80	29	93.5	
30	32.5	47.5	30	64	80.5	30	94	
31	33	48	31		81	31		

FIGURE 2

PERCENT OF TOTAL ANNUAL LOSS SPOTTED ON ANY DATE

OREGON AND WASHINGTON PERIOD OF 1923 - 1939

1153 OBSERVATIONS